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GUYTON DE MORVEAU'S COURSE OF CHEMISTRY IN THE DIJON ACADEMY

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Scientific activity in 18th-century France was by no means confined to the capital, and there were flourishing academies in several provincial towns[1]. One of the most important was the *Académie des Sciences, Arts et Belles-Lettres de Dijon*, to which Louis Bernard Guyton de Morveau (1737–1816) was elected as an *honoraire* in 1764. He was then twenty-seven years old, and had for two years been *avocat-général du roi*, one of the public prosecutors, in the Dijon parliament[2].

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[1] Four of these have been the subjects of recent studies. See: G. Martin, "Documents de l'Académie de Rouen concernant l'enseignement des Sciences au XVIII^e siècle", *Rev. Hist. Sci.*, 1958, **11**, 207–26; L. Dulieu, "Le mouvement scientifique montpelliérain au XVIII^e siècle", *ibid.*, 1958, **11**, 227–49; J. Torlais, "L'Académie de la Rochelle et la diffusion des Sciences au XVIII^e siècle", *ibid.*, 1959, **12**, 111–25; J. Cousin, "L'Académie des Sciences, Belles-Lettres et Arts de Besançon au XVIII^e siècle et son oeuvre scientifique", *ibid.*, 1959, **12**, 327–44.

[2] Biographical information about Guyton has been obtained from A. B. Granville, "An account of the life and writings of Baron Guyton de Morveau", *J. of Science and the Arts*, 1817, **3**, 249–96, and Georges Bouchard, *Guyton-Morveau, chimiste et conventionnel*, Paris, 1938. Information about the Dijon Academy has been obtained mainly from Ph. Milsand, *Notes et documents pour servir à l'histoire de l'Académie de Dijon*, 2nd ed., Paris, 1871.

At first Guyton's contributions to the Academy were literary, but he was interested in science and in 1768 he installed a chemical laboratory in his house. He devoted to chemistry all the time that he could spare from his parliamentary duties, and read papers to the Academy on many topics; most of them were published in the *Mémoires* of the Dijon Academy or in Rozier's *Observations sur la Physique.*

In 1769 Guyton began to correspond with P. J. Macquer[3], the doyen of French chemists, and he was elected a corresponding member of the Paris Academy of Sciences in March, 1772, shortly before the publication of his first book, *Digressions académiques* (Dijon, 1772). In a long essay in that book he proved for the first time that metals always gain in weight on calcination. His explanation in terms of the phlogiston theory was unsound[4], but the excellent experimental work was praised by Macquer and other members of the Paris Academy of Sciences, and this essay was largely responsible for drawing Lavoisier's attention to the problem of calcination and combustion[5].

In the same year, 1772, Guyton was elected Vice-Chancellor of the Dijon Academy, and soon afterwards the Academy acquired a new building with room for a laboratory. On 15 January, 1774, he reported this to Macquer, and added, "When it is fitted up, I shall, perhaps, with the help of some colleagues, dare to give some public demonstrations in order to spread knowledge of this fine science as widely as possible". Guyton may at first have intended to give only a few lectures and demonstrations, but later in the year his ambition was to give a complete course of chemistry, and at the public meeting of the Academy on 17 November, 1774, he read a memoir describing the advantages of such a course and showed that many kinds of people could benefit from it[6].

After declaring that in the 18th century anyone who considered himself well-informed should blush if he had no knowledge of chemistry, Guyton pointed out that this knowledge could be readily acquired in Paris, where

[3] Eighteen letters from Guyton to Macquer are in the Bibliothèque Nationale, Paris (MS. français, 12306, ff. 123–57). The first is dated "14 avril 1762", but the contents show that this was due to a slip of the pen, and it was really written on 14 April, 1769. Another letter is in the possession of Mr. D. I. Duveen (see footnote 10, below).

[4] For an account of Guyton's explanation see J. R. Partington and D. McKie, *Annals of Science*, 1937, **2**, 388 ff.

[5] H. Guerlac, "The origin of Lavoisier's work on combustion", *Arch. int. Hist. Sci.*, 1959, **12**, 113–35. Guyton's proof of the gain in weight on calcination is discussed in pp. 121–4.

[6] This was published as a pamphlet of 19 pp., 4to, entitled *Mémoire sur l'utilité d'un cours public de chymie dans la ville de Dijon, les avantages qui en resulteroient pour la province entière, et les moyens de procurer à peu de frais cet établissement*, Dijon, 1775.

many chemists gave private instruction, but in the provinces public courses were essential. He had in mind the cultured men and women who wished to be familiar with developments in science—not only Frenchmen, but also those foreigners who were in the habit of travelling to complete their education. The man who was intent on mastering the subject would have the time and energy to study many books and practise laboratory techniques, and this could be done without a teacher. Here Guyton was speaking from his own experience, for it was in this manner that he had become a chemist.

A good course of chemistry would also cure those adepts who, carried away by the reputation of alchemy, squandered their time, their energy and the patrimony of their children. There were, said Guyton, more of these than was generally realized. When he had begun to study chemistry his intentions had been misunderstood, and he had been approached by several adepts of various kinds, most of whom had suffered losses as a result of their alchemical pursuits; on finding that he was not interested, they were sorry that they had confided in him. A chemical education would eliminate this folly, which was based on ignorance[7].

Guyton then showed that a course of chemistry would be useful to many professional men, manufacturers and artisans. Chemistry was of inestimable value in medicine, but only doctors who had graduated from a university had attended chemistry lectures. Many sick people were treated by apothecaries or rural surgeons, whose ignorance of chemistry often led them to prescribe useless or even harmful substances, or to mix two remedies which reacted to form an inert substance or a poison. Lectures on materia medica could be included in the course of chemistry, and students of surgery could learn how to recognize some drugs by attending the course of botany that was already given by the Academy[8].

Chemistry could also lead to improvements in agriculture, and in such

[7] It has been pointed out by J. Read (*Prelude to Chemistry*, 2nd edn., Scientific Book Guild, London, 1961, p. 31) that alchemical traditions lingered until late in the 18th century.

[8] Jean-François Durande (1732–94) gave his first public course of botany in the summer of 1773, in the botanical garden that had been presented to the Academy by Bénigne Legouz de Gerland (1695–1774). In 1789 he was succeeded by his son, Claude-Antoine Durande (1764–1835), who lectured until 1793. From 1777, the botany course was given after the chemistry course, which usually ended in May. See A. Baudot (*Etudes historiques sur la pharmacie en Bourgogne avant 1803*, Paris, 1905, pp. 477–518) for useful information about the courses of botany, chemistry and materia medica in Dijon. The dates given by Baudot are often inaccurate. Ph. Milsand (*op. cit.*, pp. 13–15) has shown that in 1775 a course of anatomy was opened by F. Chaussier (1746–1828), who later helped Guyton (and ultimately succeeded him) in the chemistry course, and that about this time the abbé Bertrand (1753–92), professor of physics at the Godran College, gave a course on astronomy under the auspices of the academy.

arts as dyeing, starching, brewing, distilling, pottery and porcelain manufacture, assaying, metal-working, glassmaking and tanning. Not all artisans and manufacturers would attend a course, but the ambitious ones might, and Guyton optimistically suggested that even if none attended the lectures the mere existence of a course in the city would cause a knowledge of chemistry to reach them eventually. The fine arts as well as the practical arts could benefit from the application of chemistry, which might lead to the discovery of new pigments. In particular, there was a need for a good white pigment which would not be discoloured by the "phlogistic vapours" in the atmosphere.

France was very backward in metallurgy. Guyton pointed out that Burgundy and other provinces were rich in ores, but they were not as fully exploited as in England, Germany, Sweden or Saxony, and many mines were being abandoned and their owners losing money for lack of knowledge of how to exploit them efficiently. He hoped that the practice of metallurgy in Burgundy and elsewhere would benefit from his proposed course of chemistry.

Having established the value of a course of chemistry, Guyton discussed the means of financing it—always a thorny problem in the academic world. In Paris, he said, people were willing to pay for such courses, but in the provinces, where the demand was small, the lectures would have to be provided free. The Academy now had a large and well-equipped laboratory and substantial collections of natural history specimens from the three kingdoms. All that was needed was an annual sum of money for the purchase of apparatus, instruments and chemicals, and for the wages of a laboratory steward. If the provincial administration granted the necessary money it would not only make the course possible, but the laboratory would be available for other purposes. Minerals and mineral waters could be analysed, and rarely-needed medicaments could be manufactured, as had already been done occasionally in Guyton's private laboratory. During epidemics the Academy's laboratory might become a large pharmacy, and at all times artisans and manufacturers could come to seek advice or to test their new products.

Guyton was a lawyer and spoke persuasively. With the support of its protector, the Prince de Condé, the Academy made a formal request to the provincial government for a grant of money, and on 5 January, 1776, the *Elus-Généraux des Etats de Bourgogne* decided to make an annual grant of 1800 livres for a free, public course of chemistry to be given under Guyton's direction[9]. Reporting this to Macquer on 9 January, 1776, Guyton said that he was particularly pleased because the money had been granted at a time of retrenchment; it came from "les fonds destinés par l'administration à

[9] *Affiches, annonces et avis divers de Bourgogne*, 23 January, 1776. 1,800 livres was equal to about £75 sterling.

l'encouragement des arts". The decision had met with general approval in Dijon, and there had already been many enquiries about the course from people of all classes and all ages. He hoped that Macquer would be pleased at this addition to his family, for all who cultivated chemistry regarded Macquer as their father, and, in turn, their students must be his grandchildren.

The course proved a success in 1776 and 1777, and on 31 December, 1777, the annual grant was increased to 3,000 livres. In a letter written to Macquer on 22 January, 1778[10], Guyton described this as a "bonne nouvelle pour les sciences", for the Academy had had to borrow money in order to finance the two courses and maintain its botanical garden and was in debt to the extent of 6,000 livres, and in addition he had personally contributed materials worth 1,200 livres from his private laboratory.

Four years later, in 1782, the two *délibérations* of the *Élus* were published[11]. The reason for this is not clear, but it may be noted that in 1782, the year of his retirement from the parliament, Guyton had been for a year Chancellor of the Academy, and at this time there seems to have been growing criticism of the cost of the courses. The second *délibération* included a favourable appraisal of the course, and it may have been published at his request in order to show that the expenditure was justified and that the course was not financed entirely by the Academy.

The first course was formally opened on 28 April, 1776, speeches being made by Guyton, who was to give most of the chemistry lectures, Dr. Hugues Maret (1726–86), the lecturer on materia medica, and Dr. J.-F. Durande, who was now to lecture on the chemistry of vegetable substances in addition

[10] This letter, owned by D. I. Duveen, was published by D. I. Duveen and H. S. Klickstein in *Osiris*, 1956, **12**, 345–6. It was then described as being addressed to Macquart; see *Isis*, 1958, **49**, 73–4, for the rectification of the name of the addressee.

[11] *Délibération de MM. les Élus-Généraux des États de Bourgogne, Qui ordonne qu'il sera payé annuellement une somme de dix-huit cents livres, pour concourir à l'établissement d'un cours annuel, public & gratuit de Chymie, dans l'Académie des Sciences, Arts & Belles-Lettres de Dijon. Du 5 Janvier 1776*, 4to, pp. (1)–4.

Délibération de MM. les Élus-Généraux des États de Bourgogne, Qui porte à trois mille livres la somme de dix-huit cents livres, accordée par la Délibération du 5 Janvier 1776, pour concourir à l'établissement de Cours annuels, publics & gratuits de Chymie, de Matiere Médicale, & de Botanique, dans l'Académie des Sciences, Arts & Belles-Lettres de Dijon. Du 31 Décembre 1777, 4to, pp. (1)–4.

Each *délibération* has the same colophon on p. 4: "A Dijon, chez A. M. Defay, Imprimeur des États, 1782". The copies in my possession are bound together with a separate unnumbered half-title: *Délibérations de MM. les Élus-Généraux des États de Bourgogne. Des 5 Janvier 1776, & 31 Décembre 1777. Pour concourir à l'établissement de Cours annuels, publics, & gratuits, de Chymie, de Matiere Médicale, & de Botanique, dans l'Académie des Sciences, Arts & Belles-Lettres de Dijon.*

to botany. The course lasted three months, with lectures and demonstrations at five o'clock on three afternoons of each week[12].

The demonstrations were prepared by two full-time assistants[13], one of whom was J.-B. Courtois, the father of Bernard Courtois who was later to discover iodine. In his memoir on the utility of a course of chemistry, Guyton had stated that the Academy's laboratory could be used for the small-scale production of medicaments, and this work was done by Courtois, who also prepared other substances such as distilled vinegar and inks[14]. When Guyton investigated many white pigments and found that zinc calx (zinc oxide) was the least discoloured by "phlogistic vapours" in the atmosphere, Courtois manufactured the material and presumably retained the profits from its sale[15].

The contents of the course were published in 1777–8 in a book of three volumes, *Elémens de chymie*[16]. The authors were not named on the title-page, but it was stated (vol. ii, p. xxi) that Guyton drew up the plan of the work, reviewed the whole manuscript before it was printed in order to ensure consistency in all its parts, and himself wrote thirteen of the twenty chapters; that Maret wrote the sections on materia medica and the chapter on volatile alkali (ammonia); and that Durande wrote the chapters on the vegetable acids and the oily solvents (spirits of wine, ether, essential and fatty oils).

[12] *Affiches, annonces et avis divers de Bourgogne*, 7 and 14 May, 1776. Guyton's short but eloquent speech was published in his *Discours publics et éloges*, Dijon, 1782, vol. iii, pp. 336–47. In 1776 and 1777 Maret lectured on materia medica immediately after Guyton on chemistry, but in 1778 the two courses were separated, with Guyton lecturing on Mondays, Wednesdays and Fridays, and Maret on Tuesdays and Saturdays. In 1787, the year after Maret's death, the course of materia medica was given in December (the same month as the chemistry course of 1787) by Dr. Mazuyer; it was later combined with the chemistry course. See A. Baudot, *Etudes historiques sur la pharmacie en Bourgogne avant 1803*, Paris, 1905, pp. 501–4.

For a good account of H. Maret, see F. Vicq d'Azyr, *Eloges historiques*, Paris, 1805, vol. iii, pp. 95–139.

[13] This was stated by Guyton in his letter to Macquer dated 22 January, 1778 (see footnote 10, above).

[14] An account of J. B. Courtois has been given by L. G. Toraude, in his *Bernard Courtois et la découverte de l'Iode* (Paris, 1921). His work for the Dijon Academy is considered in pp. 10–23. Toraude (p. 14n) mentions another laboratory assistant, Gaucherot, employed only until 1779. He was probably the second assistant to whom Guyton referred in his letter to Macquer on 22 January, 1778.

[15] L. B. Guyton de Morveau, "Recherches pour perfectionner la préparation des couleurs employés dans la peinture", *Mém. Acad. Dijon*, 1782 (1st semestre), 1–24.

[16] *Elémens de chymie, théorique et pratique, rédigés dans un nouvel ordre, d'après les découvertes modernes, pour servir aux cours publics de l'Académie de Dijon*, 12mo, 3 vols., Dijon, L. N. Frantin, 1777, 1777, 1778. In my bibliographical study of Guyton (*Ambix*, 1957, **6**, 18–34) I gave incorrect collations of this work, and of some others. I shall rectify these errors in a forthcoming publication.

The first hundred pages contained, as an introduction to the subject, definitions and explanations of the terms commonly used in chemistry, descriptions of apparatus and experimental methods, and a brief account of the theory of affinity and the use of tables of affinity. Then followed an outline of natural history, in which the most important animal, vegetable and mineral substances were described and classified. Only the mineral kingdom was treated in detail; it was divided into the classes of earths, metals, semi-metals, salts, bitumens, volcanic materials and mineral waters.

The arrangement of the rest of the work was governed by Guyton's theory that there was a mutual attraction between the ultimate particles of the different kinds of matter, that this attraction could cause one substance to dissolve in another, and that a chemical change was possible only as a result of such a solution[17]. Every chemical operation therefore required a *solvent* and a *base* (dissolved substance). Some substances could act either as a solvent or a base, and in any particular case the name "solvent" was given to the more essentially fluid of the two reactants. There were twenty solvents and thirty bases.

SOLVENTS

Three simple elements:	fire, air and water.
Six mineral acids:	vitriolic, nitrous (nitric), marine (hydrochloric), *aqua regia*, arsenic (arsenious), sedative salt (boric acid).
Two vegetable acids:	vinegar (acetic acid) and tartarous (tartaric acid).
One animal acid:	phosphoric.
Three alkalis:	vegetable (potash), mineral (soda) and volatile (ammonia).
Four oily substances:	spirit of wine (alcohol), ether, essential oils and fatty oils.
One metallic fluid:	mercury.

BASES

Three simple elements:	fire, air and water.
Four earths:	vitrifiable earth (quartz, together with other more complex minerals), earth of alum, lime and magnesia.

[17] See W. A. Smeaton, "Guyton de Morveau's contributions to the theory of affinity". This paper was read at the *Colloque international sur l'histoire de la chimie au XVIII^e siècle*, held in Paris in September, 1959. It will eventually be published.

Three alkalis:	vegetable, mineral and volatile.
Four perfect metals:	gold, platinum, silver and mercury.
Four imperfect metals:	copper, lead, tin and iron (these were more easily calcined than the perfect metals).
Six semi-metals:	antimony, bismuth, zinc, arsenic, cobalt and nickel (these were less ductile than the perfect and imperfect metals).
Six oily substances:	Bitumen, essential oil, fatty oil, resin, gum and spirit of wine.

The solvents were treated separately, one to a chapter, and as far as possible in the same systematic manner. The natural sources of each were named and its methods of extraction or preparation described, and then followed a description of its properties and an account of its action, if any, on each of the bases in turn, and descriptions of the products of these reactions. The theoretical discussion was accompanied by accounts of relevant experiments and of the most important industrial and medical applications of the substances described.

Until this time chemistry textbooks had generally been arranged according to the occurrence in nature of the various substances. Guyton's *Elémens de chymie* was perhaps the first to be based on a theory of chemical reaction, and its novel and systematic arrangement made it very easy for the reader to refer to the action of any substance on another or to the properties of any compound. Much of the information was made even more accessible in the large "Table synoptique des dissolvans chymiques et des bases les plus simples, et des produits de leur union" which accompanied the book. The names of the solvents stood at the heads of twenty vertical columns, and those of the bases at the sides of thirty horizontal rows, and in the rectangle formed at the intersection of each column and row was printed the name of the product, if any, of the union of the solvent and base. At this time Guyton used the traditional chemical nomenclature, but he was already critical of it, and after 1782 he presumably used his own reformed nomenclature in his annual course[18].

When he began to give the course Guyton accepted the phlogiston theory, and he tried, with some success, to accommodate within it Lavoisier's new discoveries concerning the part played by air in combustion and calcination. Early in 1774 Lavoisier had sent him a copy of his *Opuscules physiques et*

[18] See W. A. Smeaton, "The contributions of P.-J. Macquer, T. O. Bergman and L. B. Guyton de Morveau to the reform of chemical nomenclature", *Annals of Science*, 1954, **10**, 87–106.

chymiques[19], and during a visit to Paris in March or April, 1775, he worked in Lavoisier's laboratory[20]. Lavoisier apparently introduced him to the techniques of pneumatic chemistry, for in a letter to Macquer, written from Dijon on 18 April, 1775, he described how he wished to pass on to his fellow Burgundians all that Lavoisier had taught him, adding, "I can already transfer air quite well from one vessel to another, to the great astonishment of my colleagues who come to see me"; and on 25 May, 1775, he wrote to the Duc de la Rochefoucauld d'Enville, whom he had also met in Paris, "At a public meeting of the Academy I have performed experiments on the seven kinds of air, all of which succeeded"[21]. The seven kinds of air, or seven gases, that Guyton could have studied in Paris in April, 1775, were probably common air, fixed air (carbon dioxide), inflammable air (hydrogen)[22], nitrous air (nitric oxide), alkaline air (ammonia), acid air (hydrogen chloride), and phlogisticated air (nitrogen). These were all described in Priestley's *Experiments and observations on different kinds of air* (vol. i, 1774).

By April, 1775, Lavoisier had shown that air, or part of the air, is absorbed during combustion and calcination, and Guyton accepted this before he gave his first course at Dijon in 1776. However, it was not until 1777–8 that Lavoisier was satisfied that the part of the air absorbed was vital air, later called oxygen, and in 1776 Guyton considered that fixed air was absorbed during combustion and calcination. He was able to reconcile this with the phlogiston theory, for he believed at this time that a metallic earth could never be observed in the pure state, but only combined with one of two fluids—phlogiston or fixed air. In the metal the earth was combined with phlogiston, which was released during calcination and replaced by fixed air from the atmosphere[23]. This theory was presumably taught in Guyton's first course in 1776, but in the *Elémens de chymie* (vol. i, p. 312) he considered that it was "air in the greatest state of purity", also called dephlogisticated air, which replaced the phlogiston. The approbation of the *Elémens de chymie* was dated 16 January, 1777, so this was probably taught in the second course in the spring of 1777.

[19] Lavoisier's draft of his letter to Guyton, sent with the book, is published in *Oeuvres de Lavoisier. Correspondance*, Paris, 1957, fasc. ii, pp. 404–6.

[20] M. Berthelot, *La révolution chimique. Lavoisier*, Paris, 1902, p. 268.

[21] Bibliothèque municipale de Besançon, MS. 1441, ff. 456–7.

[22] It was already recognized (e.g. by Priestley) that inflammable air from organic matter differed in some respects from inflammable air prepared by the action of metals on acids, but they had not yet been clearly distinguished.

[23] L. B. Guyton de Morveau, "Conciliation des principes de Sthaal (*sic*) avec les expériences modernes sur l'air fixe", *Obs. sur la Phys.*, 1776, **7**, 389–95.

The theory that the absorption of dephlogisticated air was accompanied by the emission of phlogiston was very similar to that developed about the same time by Macquer[24]. Guyton supported it until his complete conversion to the anti-phlogistic theory early in 1787, but although he held his own views on such topics as combustion, the nature of the different gases and the composition of acids, he recognized that there were other theories, and in his lectures he gave a fair account of them. During his course in 1786 he exhibited a table in which, using symbols similar to Bergman's, he gave the compositions of the more important substances according to seven different theories: first, that of the orthodox phlogistonists, and then the theories of Kirwan, Scheele, Lavoisier, Volta and Crell, de la Métherie, and Guyton himself[25].

As well as discussing the various theories of chemistry, Guyton also taught and demonstrated the latest experimental discoveries, but only after he had himself confirmed them. A list of about twenty-five new experiments introduced into the course in 1785 included the measurement of specific heats, experiments on tungstic and molybdic acids and on several new organic acids, and the production of inflammable gas from water and iron[26]. These were all recent additions to science, and Guyton's course must have been very stimulating to his audience.

Guyton was a very fine lecturer, and each year his audience grew larger. As in Paris, it became fashionable to attend scientific courses, and the audience included many ladies and gentlemen from Dijon society, but some people attended for professional reasons. These were the men who wished to become apothecaries in Dijon. On 26 October, 1782, the *Chambre de la Ville* decreed that no one would in future be allowed to become an apothecary unless he had attended courses of chemistry and botany for two years, and passed an examination. The essential part of the *délibération* reads as follows:

> "La chambre a ordonné et ordonne qu'à l'avenir nul ne pourra être admis dans le Corps des maîtres apothicaires de cette ville, et en exercer la profession, qu'il n'ait justifié d'un certificat de deux ans de fréquentation des cours de chimie et de botanique, soit dans cette ville, soit dans d'autres où ces cours sont établis; qu'il n'ait subi un examen public devant la Chambre, à la manière accoutumée, et répondu sur les questions qui lui

[24] See L. J. M. Coleby, *The chemical studies of P. J. Macquer*, London, 1938, pp. 31 ff.

[25] *Obs. sur la Phys.*, 1787, **30**, 45–6, with the table after p. 80. An analysis of this table, which has been reprinted by E. W. J. Neave (*Annals of Science*, 1952, **8**, 39) will be given in a later communication.

[26] *Nouv. Mém. Acad. Dijon*, 1785 (sem. 1), p. vi. Unfortunately the list did not include details of the experiments.

seront faites tant sur la chimie que sur la botanique, par les maîtres apothicaires, par les autres personnes qui ont droit d'y assister, et en outre par les professeurs de chimie et de botanique"[27].

Some of the literary members of the Dijon Academy had never felt at ease in the company of the scientists and doctors, and they were angered when the Academy ran into debt on account of the course of chemistry. The two factions were kept at peace by Dr. H. Maret, Secretary since 1764, and when he died in 1786 the Academy nearly died with him.

In an effort to save the situation Guyton accepted the office of Secretary and held it for a short time in addition to that of Chancellor. He described his election in a letter written on 27 July, 1786, to his friend P.-L. Baudot, who was then in Paris[28]. "Vous ne pouvez vous figurer à quel point sont venus les troubles à l'academie, si je ne consultois que mon interet, je resterois chez moi tranquille, mais je crois en devoir la sacrifice à la conservation d'un etablissement patriotique pour lequel j'ai tant travaillé. Etes vous envieux d'en savoir la source? La voici: après la perte irreparable de M. Maret j'etois loin de penser à la place de secretaire, je desirois qu'elle fut donné à M. Chaussier[29], on trouva mille vains pretextes pour l'exclure, en avouant son merite et ses droits, les litterateurs avoient resolu de la donner à l'un d'eux, je vis les sciences perdus, je reclamai avec force et chaleur le voeu du fondateur, la loi de l'academie, ses vrais interets, j'interprettai tout haut celui qui m'avoit avoué le voeu du parti formé *d'exclure medecins et chirurgiens* et qui fut obligé de l'avouer; un du parti meme m'offrit la place, l'acclamation qui devint generale entraina les malintentionnés, et me forca d'accepter pour la paix; me voila secretaire. Mais au fond les gens de lettres, c'est à dire les professeurs du college, n'ont pas abandonné le projet de faire dominer leur parti . . .".

As Guyton feared, his election did not pacify the literary members of the Academy, and a letter written to P. Picot, Baron de la Peyrouse[30] on 7 September, 1786, shows that he was almost in despair. "La mort de notre secretaire est la mort de notre académie, les gens de lettres ont fait parti pour y ecraser

[27] A. Baudot, *Etudes historiques sur la pharmacie en Bourgogne avant 1803*, Paris, 1905 p. 512. Baudot quotes the complete *délibération*, and discusses its effects.

[28] Nineteen letters from Guyton to P.-L. Baudot, written between 23 July, 1785, and 19 May, 1789, are in the Bibliothèque publique de Dijon MS. 1181, ff. 153–178.

[29] François Chaussier (1746–1828), a surgeon who had begun to give a course of anatomy in 1775, and who assisted Guyton in his chemistry course after 1781. He became secretary of the Academy in 1791.

[30] Bibliothèque du Muséum d'Histoire Naturelle, Paris, MS. 1992, No. 474. This collection contains ten letters (Nos. 465–474) written by Guyton to La Peyrouse, a member of the Academy of Toulouse, between 1 May, 1779, and 7 September, 1786, and an eleventh (No. 475) written on 5 May, 1792.

tous ceux qui cultivent les sciences, j'avois rempli ses fonctions pour laisser calmer les esprits, mais je suis devenu moimeme l'objet des hostilités, je vois la necessité de ceder au nombre des opinions et de rester chez moi, aussi bien qu'y ferois je? il n'y aura probablement plus de cours, de cahiers semestres, de correspondances &c si je vous nommois ceux qui font tout ce tapage, vous me demanderois qui ils sont, car tous nos professeurs de sciences, tous ceux qui impriment dans nos memoires sont reduit comme moi a signer des protestations que le nombre rend impuissantes. j'ai voulu seulement achever le 2^{d} semestre, vous y verres un fragement de mon article acier en forme de premier mémoire"[31].

When the majority became hostile to Guyton he must indeed have felt bitter, for his lectures and writings had brought international fame not only to himself but to the Academy. Early in 1787 he went to Paris, where he remained for several months. Working in Lavoisier's laboratory, he soon became completely converted to the anti-phlogistic theory, and he collaborated with Lavoisier, Fourcroy and Berthollet in completely revising chemical nomenclature in accordance with the new theory[32]. He returned to Dijon at the end of August or beginning of September, and at first continued to take no part in the work of the Academy. "Notre académie est toujours comme cy devant . . . je ne sais plus s'il y a du remede à tout le mal, je m'en console en restant chez moi"—so he wrote to Baudot on 13 September, 1787.

However, by the end of November, 1787, the rival factions were pacified by the Prince de Condé, the Protector of the Academy, and Guyton resumed his office of Chancellor[33]. There had been no course of Chemistry in the spring of 1787, so Guyton gave it in December, and it included a complete account of the anti-phlogistic theory. On 10 January, 1788, he wrote to Baudot: "il est vrai que les troubles de l'académie sont appaisés, on a formé délibération pour le retablissement des classes, donné un secretaire pour les

[31] Every six months a volume of the *Nouveaux Mémoires* of the Academy was published. Guyton's "Examen des faits qui doivent servir de base à la théorie de la conversion de fer en acier" appeared in *Nouv. Mém. Acad. Dijon*, 1785 (sem. 2), 406–13. This memoir was part of Guyton's long article, "Acier", in his *Encyclopédie Méthodique, Chymie*, Paris, 1789, vol. i, pp. 420–65.

[32] For accounts of the conversion of Guyton and Berthollet to the anti-phlogistic theory see D. I. Duveen and H. S. Klickstein, *Osiris*, 1956, **12**, 342–67 and J. R. Partington, *Chymia*, 1959, **5**, 130–7; for Fourcroy's conversion see W. A. Smeaton, *Endeavour*, 1959, **18**, 70–74.

[33] In 1789 Guyton was succeeded as Chancellor by de Montigny, *trésorier des Etats*, and he became again Vice-Chancellor, an office he had held from 1772 to 1781 (Ph. Milsand, *op. cit.*, p. 321).

sciences[34] et reunis les cours sur l'ancien pied, c'est M. le P. de Condé qui a negocié cet arrangement . . . nous avons fait le cours de 1787 du 1er an 31 Xbre . . . cela m'a un peu ecrasé . . . j'ose dire que ce cours a eté neuf et très interessant par les experiences fondamentales de la nouvelle doctrine, on m'en demande le resumé, mais je ne sais où le placer. Le redacteur du jal physique se déclaire de maniere à rompre avec les gens honnetes, je ne vois pas d'autre journal, je l'ai envoyé en Allemagne, il reviendra peut etre par traduction en France".

The editor of the *Journal de Physique* (the name frequently given at that time to *Observations sur la Physique*) was J. C. de la Métherie, an opponent of the new theory, who had attacked the new nomenclature in a manner that could not have endeared him to Lavoisier and his colleagues[35]. Supported by Lavoisier, P. A. Adet tried to obtain the legal permission to publish a new journal containing translations from Crell's *Annalen* and other chemical memoirs. Guyton must have been aware of Adet's plan, and he had, in fact, sent a summary of his new course to Crell, who published it in the *Annalen* in 1788[36].

In this short memoir Guyton was able to describe only a few of the experiments by which he had demonstrated in various ways the formation and decomposition of water and other important phenomena supporting the new theory. Some of the experiments had been performed by other chemists, but they were probably new to his audience, and sometimes he was able to improve the technique. He showed, for example, that when pure and well-dried charcoal was heated in a porcelain retort, neither inflammable air nor fixed air was expelled, but when it was heated in a bell-jar of vital air over mercury, fixed air was formed and on cooling the volume was practically unaltered. When Lavoisier performed this experiment he generally ignited the charcoal by means of a red-hot bent iron rod, but Guyton succeeded in

[34] Guyton's election as secretary of the Academy after Maret's death was not recorded by Milsand, who named Caillet (1736–1822), professor at the Godran College, as Maret's successor in 1786, Pierre Jacotot (1755–1821) as secretary in 1787, and François Chaussier (1746–1828) as secretary in 1791 (Ph. Milsand, *op. cit.*, p. 324). Jacotot was presumably the "secretaire pour les sciences" to whom Guyton referred; he later gave a course of physics in Dijon (see footnote 44, below).

[35] De la Métherie gave an uncritical account of the new nomenclature in the number of *Obs. sur la Phys.* for September, 1787 (pp. 210–9), but followed this with a severe criticism in October (pp. 270–85). An anonymous attack on the nomenclature appeared in the December number (pp. 418–24).

[36] "Nachricht von einigen vorzuglichen Versuchen, welche vom Hrn. de Morveau in den öffentlichen Vorlesungen der Akademie zu Dijon angestellt wurden", *Crell, Annalen*, 1788, Bd. 2, 118–31. In this paper Crell used a German version of the old chemical nomenclature. I have used the English version of the new nomenclature of 1787, since that was probably used by Guyton in his lectures.

introducing a red-hot piece of charcoal through the mercury. He also repeated Kirwan's conversion of sulphur into acid by heating with calx of mercury[37], but he improved on Kirwan's technique by replacing the common air in the retort by azote (nitrogen), so that there could be no possibility of ignition of the sulphur.

Guyton noted that Priestley had observed the reaction between sulphur and water[38], but had had trouble with his apparatus. Guyton modified the experiment by melting sulphur in a retort filled with azote, and allowing pure water (boiled to free it from oxygen) to fall on the sulphur drop by drop from a tap-funnel fixed into the neck of the retort. So long as the water fell directly on to the molten sulphur the reaction proceeded smoothly, but sometimes water was liable to rush into the retort from the vessel in which the liberated gas was being collected. Guyton overcame this problem by fitting a valve on the neck of the retort, where it entered the water.

It may be mentioned here that Guyton devised much ingenious apparatus for investigating the chemistry of gases, but unfortunately he did not generally publish accounts of it. Arthur Young visited his laboratory in July, 1789, and gave a short description. "It consists of two large rooms, admirably furnished indeed. There are six or seven different furnaces (of which Macquer's is the most powerful), and such a variety and extent of apparatus, as I have

[37] R. Kirwan, *An essay on phlogiston and the constitution of acids*, London, 1787, pp. 29–30. Kirwan incorrectly considered that the calx of mercury contained fixed air and the sulphur contained phlogiston.

[38] J. Priestley, *Experiments and observations relating to various branches of natural philosophy*, Birmingham, 1786, vol. iii, p. 150. Priestley's account of the experiment was quite short: "Transmitting steam over a quantity of *sulphur*, which was melted in a hot earthen tube, I procured from it a considerable quantity of inflammable air, without any fixed air; and by analysis it appeared to be of the same quality with that which is procured from iron by oil of vitriol. This process is rather troublesome, on account of the sulphur subliming, and filling up the tubes through which the air is conveyed". Priestley was wrong in identifying the inflammable air with that obtained from iron and oil of vitriol (i.e. hydrogen). The reaction between sulphur and water (or steam) always yields hydrogen sulphide, together with sulphurous acid, thiosulphuric acid or one of the polythionic acids, according to the conditions of the experiment; sulphuric acid is rarely formed in the absence of air. (*Gmelins Handbuch der anorganischen Chemie*, 8th ed., 1953, Schwefel, Teil A, pp. 690–2.) Guyton stated that he obtained sulphuric acid; probably the azote with which he filled the retort contained some oxygen. The gas was described in his memoir merely as inflammable air (*brennbare Luft*). Hydrogen sulphide was not yet recognized as a separate compound, as distinct from a mixture, and in the *Méthode de nomenclature chimique* (Paris, 1787, p. 98) it was called "le gaz hydrogène sulfuré ou la dissolution du soufre dans le gaz hydrogène". In a manuscript of a lecture course given about this time A. F. Fourcroy explained that the sulphur was in suspension in the hydrogen, and not combined with it. (Bibliothèque publique de Dole, MS. 171, f. 109 v.)

seen no where else, with a furniture of specimens from the three kingdoms, as looks truly like business. . . . He has a pair of scales made in Paris, which, when loaded with 3,000 grains, will turn with the twentieth part of a grain[39] . . . and abundance and most ingenious inventions for facilitating enquiries in the new philosophy of air. These are so various, and at the same time so well contrived to answer the purpose intended, that this species of invention seems to be one very great and essential part of Mons. de Morveau's merit; I wish he would follow Dr. Priestley's idea of publishing his tools, it would add not inconsiderably to his great and well-earned reputation . . ."[40].

Guyton's originality was apparent in some more of the experiments described in his communication to Crell. He believed that the difficulty of converting carbon to carbonic acid caused people to have doubts about the true nature of carbonic acid, and especially the carbonic acid exhaled by animals, which, according to Lavoisier, was formed in the lungs by combination between carbon in the blood and oxygen in the air. He was now able to report that he had converted carbon to carbonic acid in the wet way, by adding charcoal dust to a mixture of pyrolusite (manganese dioxide) and muriatic acid from which oxymuriatic acid (chlorine) was obtained, and also by simply allowing powdered charcoal to stand in a solution of oxymuriatic acid. In the second experiment the solution was able to precipitate lime-water after a few hours[41]. Guyton hoped that this demonstration of the preparation of carbonic acid from carbon in the wet way would help to convince the doubters that carbon in the blood could be converted to carbonic acid without ignition.

One of the remaining experiments described is particularly noteworthy. Tin and nitric acid were heated in a retort, which was connected to a receiver packed with ice, two Woulf flasks, and a pneumatic trough. Most metals yielded a gas (generally nitric oxide) when heated with nitric acid, but in this case no gas reached the pneumatic trough. This unexpected phenomenon caused Guyton to remember the observations of Pott and Higgins, and Berthollet's discovery that ammonia was a compound of azote and hydrogen,

[39] 3,000 grains was about six ounces. This balance may be compared with that made by Mégnié for Lavoisier, which weighed to 18 or 20 ounces with a precision of a tenth of a grain. See M. Daumas, *Lavoisier, théoricien et experimentateur*, Paris, 1955, p. 135.

[40] A. Young, *Travels during the years* 1787, 1788 *and* 1789 . . . *(in) the Kingdom of France*, Bury St. Edmunds, 1792, p. 152.

[41] Guyton did not state how he identified the carbonic acid in the first experiment. In the second experiment the carbon was probably oxidized by the hypochlorous acid that is present in chlorine water. L. S. Sproesser (*Z. für Elektrochemie*, 1900–1, 7, 1091) found that the reaction is $C + 4HOCl = CO_2 + 2Cl_2 + 2H_2O$. Guyton, of course, considered that oxygen from the oxymuriatic acid (chlorine) was transferred to the carbon, forming carbonic acid and muriatic acid.

and he suspected that ammonia had been formed from the azote of the nitric acid and the hydrogen of the water that was present. He therefore examined the residue left after the contents of the retort were evaporated to dryness, and found that it consisted of a mixture of oxide of tin and nitrate of ammonia, with some free nitric acid[42].

Guyton's hope that his communication to Crell would be translated into French was not realized, for in 1789 Lavoisier and his colleagues, including Guyton, were able to publish a new journal, *Annales de Chimie*, and they did not take advantage of the permission to translate Crell's *Annalen* that had been granted in 1788.

His letters to P.-L. Baudot show that Guyton gave two more courses of chemistry in Dijon, in 1788 and 1789. On 28 July, 1788, he wrote, "notre cours est commencé depuis 6 semaines, la nouvelle doctrine va grand train, chaque jour nous avons des expériences demonstratives", and on 19 May, 1789, "notre cours n'est pas fini, il a eté fort suivi, et par des gens déjà initiés". In 1788 the course was attended by some artillery officers, for whose pleasure (so he wrote to P.-L. Baudot on 23 August, 1788) he had prepared a historical account of the fate of the phlogiston theory which he was going to read at a public meeting of the Academy on 24 August.

No further lectures were given by Guyton in Dijon, for in 1790 he was elected to the Legislative Assembly, and he spent the rest of his life in Paris.

[42] It is interesting to see that in 1788 Guyton referred to J. H. Pott and [William] Higgins. In the same year Berthollet (*Mém. Acad. R. Sci.*, 1785 (pub. 1788), 325–6) drew attention to the fact that these two chemists had obtained volatile alkali (ammonia) from mineral substances. Pott's observation that a "urinous spirit" was produced by the action of zinc on nitre in certain conditions was published in his dissertation on zinc in *Observationum et animadversionum chymicarum praecipue zincum, boracem et pseudogalenam . . .*, Berlin, 1741, p. 31 (French translation by Demachy in *Dissertations chymiques de M. Pott*, Paris, 1759, vol. iii, pp. 466–7). William Higgins obtained volatile alkali in 1785 by adding potash to the product from the reaction between tin and nitrous (nitric) acid, but did not publish his discovery until 1789, in his *Comparative view of the phlogistic and anti-phlogistic theories*. T. S. Wheeler and J. R. Partington (*The life and works of William Higgins*, Oxford and London, 1960, p. 106) consider that Guyton knew nothing of Higgins's experiment; however, it was evidently known, at least a year before it was published, to both Berthollet and Guyton. It may have been described to them by Thomas Beddoes, who had learnt about it from Higgins in June, 1787 (when Beddoes was "chemical reader" in Oxford) and who visited Dijon and Paris in the autumn of 1787. (See F. W. Gibbs and W. A. Smeaton, "Thomas Beddoes at Oxford", *Ambix*, 1961, **9**, 47–49). A short account of Higgins' experiment was published by W. Austin (*Phil. Trans.*, 1788, **78**, 380–81: see Wheeler and Partington, *op. cit.*, p. 105). He had seen the experiment performed "some years" before 1788 at Sir Joseph Bank's house, but he did not mention Higgins by name, and it cannot have been from Austin's account that Guyton learnt of Higgins' work.

The course of chemistry at Dijon was given in 1790 and 1791 by Chaussier, who had been Guyton's colleague since 1781[43], and according to A. Baudot, Chaussier also lectured in 1792 and 1793. All the French academies were suppressed by the Jacobin government in August, 1793, and by the time that the Dijon Academy was revived in 1798 other arrangements had been made for scientific instruction in the town, and the Academy was no longer responsible for courses of lectures. On 24 April, 1795, the *Commission des Sciences et des Arts de la Commune de Dijon* decided to re-establish free courses of botany, mineralogy, chemistry and materia medica, to be given by C.-A. Durande and Antoine, and a course of physics was later organized with Jacotot as the professor[44].

In 1795 Guyton once again began a course of lectures, at the newly founded Ecole Polytechnique in Paris, where he was one of the professors of chemistry until 1811.

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[43] This was stated in *Ann. de Chim.*, 1815, **95**, 323.

[44] A. Baudot, *Etudes historiques sur la pharmacie en Bourgogne avant 1803*, Paris, 1905, pp. 485, 505.

WILLIAM DAVIDSON OF ABERDEEN

THE FIRST BRITISH PROFESSOR OF CHEMISTRY

By John Read, F.R.S.*

Introduction

Until the time of Paracelsus (1493–1541), alchemy, the precursor of chemistry had been engaged for a millennium in the pursuit of the Philosopher's Stone, an imagined transmuting agent and elixir of life. Alchemy was based upon two *a priori* assumptions and two rudimentary theories. The assumptions were the unity of matter and the existence of the Philosopher's Stone, and the theories were those of the Four Elements and the derived Sulphur-Mercury Theory of metals. The chief goal of alchemy was the achievement of the Stone through the operations of the Great Work[1].

In the first half of the 16th century Paracelsus gave a new direction to alchemy and greatly enlarged its scope by allying it with medicine. The true goal of alchemy, he insisted, must be to prepare medicines instead of seeking gold. The ensuing period of iatro-chemistry, spagyric chemistry, or chemistry applied to medicine, lasted from the 16th into the 18th century. Meanwhile the old alchemy still persisted, but slowly declined. Paracelsus modified the ancient sulphur-mercury theory by introducing a third principle which he termined salt. In this system of the *tria prima*, often represented symbolically by a triangle, the names sulphur, mercury and salt had both a chemical and mystical significance. Chemically they stood for inflammability, metallicity and fixidity; mystically for the soul, spirit and body of man.

In medicine, the herbalist of the ancient Galenic order now became a pharmacist, or compounder of chemical medicines. The Paracelsian ideas were pushed to extremes by later enthusiasts, such as Dubois Sylvius in the 17th century, who saw in the human body, "nothing but a magna of humours continually in fermentation, distillation, effervescence or precipitation; and the physician was degraded by him to the rank of distiller or brewer"[2].

The end of the 17th century found iatro-chemistry on the wane; but during the period of transition the iatro-chemists, despite their excesses, had promoted

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[1] For details of alchemical theory see J. Read, *Prelude to Chemistry*, London, 1939, reprinted 1961; also *The Alchemist in Life, Literature and Art*, London, 1947, and *Through Alchemy to Chemistry*, London, 1957, reprinted 1961.

[2] T. Thomson, *The History of Chemistry*, 2 vols., London, 1930–31, **1**, 196.

the steady growth of chemical knowledge. The gradual change from alchemy to chemistry became evident in a notable succession of early textbooks of chemistry published in the 17th century. Of these, the earliest was due to Jean Beguin, who was the first to give public lectures on chemistry in Paris, combined with practical instruction in pharmacy. In 1610, as a guide to his students, he published a small book entitled *Tyrocinium Chymicum*, or "The Chymical Beginner", the first French edition of which appeared in 1615 as *Les Elemens de Chymie*. During the 17th century some fifty editions of this book were published in various languages. Beguin was a follower of Paracelsus, and his book stressed the practical rather than the theoretical view of chemistry.[3]

This book was followed in 1633–35 by the *Philosophia Pyrotechnica* of William Davidson, who continued the teaching tradition set up by Beguin in Paris and eventually became the first professor of chemisty at the Jardin du Roi in 1647. Davidson was succeeded in this post by Nicholas le Fevre, or Nicasius le Febure, whose *Traicté de la Chymie* (Paris, 1660) was translated into English in 1664 under the title *A Compleat Body of Chymistry*. This admirable book ranked for a century as a standard treatise. Le Febure's successor at the Jardin, Christophle Glaser, also published, in 1663, a similar and very successful work entitled *Traité de la Chymie*. The greatest and most lasting success of all, however, was achieved by Nicholas Lemery's *Cours de Chymie*, first published at Paris in 1675. This work "did more to bring chemistry to the popular notice than any other work published before the birth of modern chemistry at the end of the 18th century".[4] Lemery held no appointment at the Jardin du Roi, but he gave in Paris a series of very popular lectures and demonstrations on chemistry. His book owed much to Glaser's.

The greatest practical chemist of the 17th century was the German, Johann Rudolph Glauber (1604–70). He was a skilful research chemist rather than a teacher; but his books exerted a widespread and stimulating effect on chemistry. Beguin, Davidson, Glaser and Lemery added little new knowledge to chemistry, "yet by their lectures and practical demonstrations they brought chemistry home in a new and efficient way to large circles of enthusiastic audiences; and they reached out to a still wider public by means of their books, all of which were made available in the vulgar tongue. Their activities, like the practical work of Glauber in its published form, developed a new and growing interest in the everyday applications of chemistry"[5].

[3] J. Read, *Humour and Humanism in Chemistry*, London, 1947, 81.

[4] *Ibid.*, p. 116.

[5] *Ibid.*, p. 126.

Davidson's Early Career

William Davidson, Davidsoune, Davissone, D'Avissone, or D'Avissonus—for his name has been spelt in many ways—was born in Aberdeenshire about 1593. Precise details of his career are sparse, although the main outline is known. In a patent of descent[6] dated 1629, his father, Duncan Davissone of Ardmakrone is described as "an honourable and respectable man", and his mother, Jonet Forbes, as "a good and virtuous woman". Through them, Davidson claimed descent from several noble Scots families, including those of Forbes, Leslie, Gordon, Huntly and Argyll.

Late in his life Davidson published at the Hague in 1660 a commentary on the *Idea Medicinæ Philosophicæ* of Petrus Severinus,[7] and in this somewhat discursive work he includes several personal references of interest. He states that his mother was left a widow in difficult circumstances at a time when the oldest of her three sons—he himself being the youngest—was barely seven years old. Not long afterwards the young family lost their mother; but in due course William was enabled to enter Marischal College, presumably through the help of relatives, and he graduated M.A. in 1617[8].

While Davidson was a young man the celebrated Dr. Duncan Liddel[9] was a familiar figure in Aberdeen, where he chiefly lived from 1607 until his death in 1613. Liddel was a graduate of King's College, Aberdeen, who had attained great eminence in the University of Helmstedt as professor of mathematics, professor of medicine, dean of the faculty of philosophy, and pro-rector. Since Davidson developed similar leading interests in medicine and mathematics and also rose to eminence in a foreign land, it is easy to imagine that he was inspired by the example of this honoured alumnus of his own University, with

[6] J. Small, *Proceedings of the Society of Antiquaries of Scotland*, 1875, **10**, 267.

[7] *Commentariorum in sublimis Philosophi et incum parabilis viri Petri Severini Dani ideam medicinæ Philosophicæ propediem produturorum Prodromus*, Hagæ Comitis, 1660. There is a copy of this in the University Library, Aberdeen.

Davidson's commentary is much longer than the accompanying book of Severinus (1542–1602), which deals with Paracelsian medico-chemistry. Another edition of this work was published at Rotterdam in 1668. The separate commentary was issued at the Hague in 1663. There is a copy of this in the University Library, St. Andrews.

[8] According to the records of Marischal College, Davidson was admitted in 1614, becoming semi in 1614–15, tertian in 1615–16, and graduating M.A. in 1617. There was no M.D. degree at Aberdeen at that time: King's College first conferred it in 1630, and Marischal College in 1713. From the very beginning, however, King's College (1505) had a "Mediciner" on its teaching staff, this being "the first university recognition of the subject in Great Britain", Cambridge following in 1540. See J. D. Comrie, *History of Scottish Medicine*, 2 vols., London, **1**, 369.

[9] See A. Gibb, *Proceedings of the Society of Antiquaries of Scotland*, 1876, **11**, 450; also J. Read, *Chymia*, 1948, **1**, 140.

whom indeed he may possibly have had personal relationships. It may have been Liddel's example that led Davidson to the conclusion, recorded in his commentary on Severinus[10], "that it was more desirable for me, a third son, to . . . live industriously and honestly among foreigners, than to live in poverty and degradation amongst my own countrymen and illustrious relatives".

Soon after graduating[11], Davidson migrated to Paris, where he spent a great part of his life. Here, according to Hoefer[12], he gave instruction in chemistry in the first half of the 17th century, beginning in the minority of Louis XIII. He had apparently qualified in medicine and pharmacy at this time. The acquirement of a certain knowledge of medicine was part of the general education of that day; but how Davidson obtained his special knowledge of these branches of learning is not clear, although it may be that he derived some instruction from Beguin, who, like Davidson himself, is said to have owed his establishment in Paris to Jean Ribit, Sieur de la Rivière[13].

In a detailed study of Davidson, published in 1898, Professor E. T. Hamy of the Muséum d'Histoire naturelle, Paris, remarks on the veil shrouding his movements at this time, during which it seems possible that he may have qualified as Docteur en Medicine at Montpellier[14]. His early marriage to a Scots gentlewoman[15] and the foundation of a strong and lasting friendship with

[10] *Proceedings of the Society of Antiquaries of Scotland*, 1875, **10**, 277.

[11] In *Les Elemens de la Philosophie de l'Art du Feu ou Chemie*, Paris, 1651, Davidson refers (p. 400) to his thirty-three years in France, thereby indicating that he arrived about 1618. In the same work (p. 553) he mentions the death of Charles I [1649], so that his comments appear to be reasonably up to date. Hamy's statement (p. 3, *op. cit.*, note 14, *infra*) that Davidson migrated to the continent towards the end of 1614 is untenable, as he was then a student in Marischal College, Aberdeen. The date 1593 which Small (*supra*) deduced for Davidson's birth, from internal evidence in his writings, corresponds to his graduation at the late age of twenty-four. However, Johann Hartmann, for example, graduated in philosophy at Marburg in 1591, when he was twenty-three.

[12] F. Hoefer, *Histoire de la Chemie*, 2 vols., Paris, 1866–69, **2**, 234.

[13] Hoefer, *op. cit.*, **2**, 103. Davidson makes an appreciative mention of Ribit in *Les Elemens* (*supra*), p. 18.

[14] E. T. Hamy, "William Davisson, Intendant du Jardin du Roi et Professeur de Chimie (1647–51)", *Nouvelles Archives du Muséum d'Histoire Naturelle*, Troisième Série, Paris, 1898, **10**, 1. A detailed bibliography of Davidson's works is appended to this paper.

[15] In Hamy's words (*op. cit.*), "Une Écossaise de petite noblesse, Charlotte de Thynny". One son, Charles, resulted from this union. Davidson's wife finds a further mention late in his life, during the Polish period (*op. cit.*, p. 20). In an article on Davidson in the *Dictionary of Polish National Biography*, 1938, **4**, 445–6, published (in Polish) by the Polish Academy of Sciences and Letters, Cracow, she is stated by A. Birkenmajer and W. Ziembicki to have taken an active part in regulating Davidson's loans of money to individuals and even to towns, including Dantzig.

Jean Baptiste Morin were among the most important events of these early years upon which any certainty exists.

It was through Morin that Davidson got to know Bishop Claude Dormy, an enthusiastic amateur of science in general and chemistry in particular. According to Hamy[16], Davidson succeeded Morin as Dormy's physician, and was thereby enabled for several years to indulge freely his passion for practical chemistry in the Bishop's laboratory at Beauchamps, near Bourbon-Lancy. The Bishop died in 1626, and possibly it was then that Davidson continued the custom set up by Beguin, who had died about 1620, of giving in Paris a combined course of lectures and practical demonstrations dealing with chemical medicines.

Le Jardin du Roi

Now in 1572, Jacques Gohorry, prior of Marsilly and friend of Jean Ribit, Turquet de Mayerne and other Paracelsians, grew a number of simples in his pleasant garden on the bank of the Seine, near the Sorbonne; beside it lay the garden of the elder Guy de la Brosse, king's mathematician, to which was attached a modest chemical laboratory. On this site, in 1626, was founded the famous Jardin du Roi[17], for the culture of medicinal plants, owing largely to the efforts of a grandson of Guy de la Brosse bearing the same name. The king's first physician, Hérouard, was appointed superintendent of the Jardin, with Guy de la Brosse, another king's physician, as intendant. On the latter's death in 1641, Bouvard, a son of the second superintendent, succeeded him. It is of interest that these developments were fostered by a group of Paracelsians, mostly Protestants, who believed fervently in the use of antimonial, mercurial, and other chemical drugs.

It is likely that Davidson developed his course of tuition in medical chemistry whilst practising as a physician and apothecary, with the support of the Paracelsians and of his numerous compatriots living in Paris[18]. Hoefer states

[16] *Op. cit.* p. 6.

[17] Le Jardin du Roi in Paris was known later as Le Jardin des Plantes. The attached institute is now known as Le Muséum national d'Histoire naturelle. Besides being a general museum, it houses the collections of preserved animals and plants comparable with the collections in the Natural History Museum at South Kensington, London.

[18] Among Davidson's clientèle as a physician in Paris, Hamy (*op. cit.*, p. 8) mentions the English ambassador, Lord Scudamore, Sir Francis Crave, Sir Robert Read, Thomas Windebank, and Sir Kenelm Digby, the great advocate of the "Powder of Sympathy".

Anent Davidson's acquaintances in Paris, there is a curious allusion in an author's note to the story, *The unparalleled adventure of one Hans Pfaal.* Here Edgar Allan Poe refers to a "somewhat ingenious little book" published at Paris in 1647 under the title, "L'Homme

continued on opposite page

that students of many nations frequented his courses, and that *Philosophia Pyrotechnica* was published for their benefit; this was his first and most important book. His reputation grew steadily; but in 1644 a parliamentary decree came into operation preventing foreign physicians not belonging to the Paris faculty from practising in that city. At this juncture, however, an influence on Davidson's behalf was exercised by Henrietta Maria, the English queen, and also by François Vautier, a friend of Morin with Paracelsian sympathies, and first physician to the King of France. Through Davidson's consequent appointment, in 1644, as a physician to the King, he was *ipso facto* absolved from the interdiction.

Meanwhile the Jardin du Roi, or Jardin royal, with its lecture rooms and laboratories, had been formally opened in 1640. "I took coach", wrote John Evelyn in his diary[19] on 8 February, 1644, "and went to see the famous Jardin Royal, which is an enclosure walled in, consisting of all varieties of ground for planting and culture of medical simples. It is well chosen, having in it hills, meadows, wood and upland, natural and artificial, and is richly stored with exotic plants. In the middle of the parterre is a fair fountain. There is a very fine house, chapel, laboratory, orangery, and other accommodations for the President, who is always one of the King's chief physicians".

Evelyn's description of the Jardin du Roi accords well with an engraving (Fig. 1) by F. Scalberge of the "Jardin des plantes médicinales en 1636", which appeared in Guy de la Brosse's *Description du Jardin royal des plantes médicinales*, published at Paris in that year. Besides the buildings, this shows the grand parterres traversed by a central avenue, with two parallel alleys bordered by hornbeams, together with apple and cherry orchards, a wood, a meadow, a tulip garden, and an overlooking hillock, Belle Vue, laid out formally and containing an elevated terrace known as Beau-Séjour. The side of the garden remote from the main building is bordered by a terraced alley overlooking a tree-lined brook.

A few years after Evelyn's visit a chair of chemistry, associated also with the teaching of botany, was founded at this institution, and upon the recommendation of Vautier, now superintendent of the Jardin, Davidson was called

[19] J. Evelyn (ed. A. Dobson), *The Diary of John Evelyn*, Globe edn., London, 1908, 32.

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[18] *continued*

dans la lvne, ou le Voyage Chimerique fait au Monde de la Lvne", of which the anonymous French writer, "J.B.D.A. Paris", states: "I'en ai eu l'original de Monsieur D'Avisson, medecin des mieux versez qui soient aujourd'huy dans la conoissance des Belles Lettres, et sur tout de la Philosophie Naturelle. Je lui ai cette obligation entre les autres, de m'auoir non seulement mis en main ce Livre en anglois, mais encore le Manuscrit du Sieur Thomas D'Anan, gentilhomme Eccossois, recommandable pour sa vertu, sur la version duquel j'advoue que j'ay tiré le plan de la mienne".

upon to fill it, following a decree of 15 April, 1647, dispossessing Bouvard as intendant. Davidson entered upon his duties at 6 a.m. on 23 July, 1648, as may be seen from the following announcement, here translated from the original Latin[20]:

Under Royal Patronage

William Davisson of Scotland, Counsellor and Physician to the King, Intendant of the Jardin du Roi—

Lays open the fount of botany and chemistry to aspirants to knowledge and learning. From the former, they will perceive careful cultivation, a new arrangement, and the addition of more than seven hundred plants. From the latter, they will apprehend the analysis of animals, vegetables and minerals. The lecturer will devote much attention to the preparation and exaltation of antimony, because words are lacking by which to name so rich a substance, which contains the vital principle, balm, and healing virtue (*mumiam*[21]) in itself. Verily, verily, I say unto you, there is no more lofty medicine under heaven.

In the Hall of the Jardin du Roi at Paris, on 23 July and thereafter, at 6 a.m., in the year 1648.

Early Chairs of Chemistry

William Davidson was the first occupant of any chair of chemistry in France, and the tercentenary of his active accession to this appointment was reached in 1948. He was the first Scots professor of chemistry; more than that, he was the first native of the British Isles to hold such a chair. Until the 17th century, chemistry, such as it was, had been taught by professors of medicine; but in 1609 Johann Hartmann (1568–1631) was appointed in the University of Marburg to give public lectures on iatro-chemistry, or medico-chemistry[22].

Twenty years later, in the University of Jena, Werner Rolfinck (1599–1673) entered upon the teaching of anatomy, surgery, botany and chemistry; and in 1639 he was installed as "Director exerciti chymici"[23]. Hartmann's appointment, like Rolfinck's, has been claimed as tantamount to the foundation of a chair of chemistry. Davidson would accordingly rank as the third professor of chemistry to be appointed in Europe; in his case no doubt exists about the definite character of the chair and the exact date of its foundation. It is of interest to add that Davidson's successor at the Jardin du Roi, Nicasius le

[20] Hamy, *op. cit.*, pp. 14, 15.

[21] See *Les Elemens* (*supra*), pp. 558, 562, 576.

[22] H. Kopp, *Geschichte der Chemie*, 4 vols., Braunschweig, 1843–47, **2**, 18; J. Ferguson, *Bibliotheca Chemica*, 2 vols., Glasgow, 1906, **1**, 366.

[23] F. Chemnitius, *Die Chemie in Jena von Rolfinck bis Knorr*, Jena, 1929.

Febure[24], became in 1660, "Royal Professor in Chymistry" to Charles II, this being the first English appointment to a professorship of chemistry.

On 21 October, 1649, John Evelyn[25] mentions that he "went to hear Dr. D'Avinson's lecture in the physical garden, and see his laboratory, he being Prefect of that excellent garden, and Professor Botanicus". Davidson's lectures on chemistry, which were presumably delivered in Latin, must have been devoted mainly to the preparation and uses of medicinal chemicals, with an explanation of the processes and apparatus concerned, as laid down in his *Philosophia Pyrotechnica* and its French version, the discussion being illustrated by practical demonstrations of the most important processes. A demonstrator was eventually provided for this latter purpose, one of the most notable of them in the following century being Guillaume-François Rouelle, the teacher of Lavoisier. For some two hundred years after the foundation of the chair of chemistry at the Jardin du Roi, the progress of chemistry in France was closely bound up with the work of the many eminent chemists who functioned in this institution as professor or demonstrator of the subject: among them were numbered Glaser, Bourdelain, the brothers Rouelle, Macquer, Gay-Lussac and Chevreul.

A charming vignette (Fig. 2) by Sébastien Leclerc in Dodart's *Mémoires pour servir à l'histoire des plantes* (Paris, 1676) shows "la leçon de chimie au Jardin royal" at that time. The professor is seated at a table, with an open book before him, a bottle in his right hand, and a bundle of dried herbs at his feet. The members of his class are adults, wearing the picturesque cloaks and broad-brimmed hats of the period; some of them are seated, while others stand around the table. A secretary, in a seat facing the professor, takes notes. A laborant attends to a furnace, and another works at a bench below a window looking out on to the gardens. The interesting display of contemporary apparatus shown at the back of the room includes a "serpent", used in rectifying spirit of wine, and described by Davidson's successor, Nicasius le Febure, as "a Vessel to alkolize the Spirit of Wyn in the very first distillation". There is also a large glass-fronted recess containing numerous pharmaceutical specimens.

It was an age of a rapidly growing interest in science, and these lectures at the Jardin du Roi, "laying open the fount of botany and chemistry", attracted "aspirants to knowledge and learning" from far and wide. Thus a note which John Aubrey wrote in his copy of the 1641 edition of Davidson's *Philosophia pyrotechnica* (later deposited in the Ashmolean Museum at Oxford) tell us that "Mr Tho. Hobbes Malmesburiensis told me that he knew him very well at Paris,

[24] *Humour and Humanism in Chemistry*, p. 101.

[25] *Op. cit.*, 151.

and that he went through a Course of Chymistrie with him. His Laboratorie was at ye upper end of the King of France's Physick-Garden".

Poland and Last Years

Besides his status as professor, Davidson held rank as Intendant of the Jardin du Roi and Counsellor and Physician to the King of France. It is therefore a matter for surprise that he resigned this distinguished appointment, after holding it for only a short period, in order to take up a somewhat similar post in far-away Poland. In the dedication of the first edition of *Les Elemens de la Philosophie de l'Art du Feu ou Chemie* (1651) to John Casimir (Jan Kazimierz), King of Poland, to whom he became first physician, Davidson mentions his approaching transition from Paris to Warsaw and says that the honour of being called to his Majesty's court will encourage him in his work, endowing his spirit with fire and zeal.

This was the shadow of a coming event. Davidson's decision, like that of his successor, le Febure, in accepting the invitation of Charles II to London, was conditioned by the growing scientific and religious intolerance prevailing at that time in France. Davidson entered upon his appointment just before the outbreak of the Fronde. Paris was in a very disturbed state, and feelings were easily inflamed. Davidson's position was uneasy from the start. There ensued a period of sordid intrigues[26] in which the displaced intendant, Bouvard, taking every advantage of religious and medical jealousies, played a despicable part. Davidson was a foreigner and a heretic, both in religion and medicine. Bouvard and his faction played these strong cards for all they were worth. In 1651, Davidson was forced to resign[27].

Davidson owed the fortunate appointment in Poland to the influence of his old friend Morin with Marie-Louise, Queen of Poland. Through her support

[26] Hamy, *op. cit.*, p. 16.

[27] According to the official announcement (Hamy, *op. cit.*, p. 17): "Le 26 juillet 1651, le sieur Davissone, Escossois, Docteur en Medecine de la Faculté de Montpellier, ayant esté mandé par le Roy de Pologne pour avoir la surintendance des jardins de Leurs Majestez Polonoises, avec dix mille livres de pension, partit d'ici, apres avoir remis entre les mains du sieur Vautier, premier Medecin du Roy, la charge qu'il lui avoit commise il y a quatre ans, d'Intendant du Jardin Royal des plantes médicinales en cette ville, et de Professeur du Roy en Chymie."

This notice contains the only known reference to Davidson as the holder of a degree from Montpellier, to which he may well have proceeded in his early days as a keen Paracelsian.

John Aubrey, in his note mentioned on p. 77 (see also Powell, A., *John Aubrey and his Friends*, London, 1948), wrote: "About 1660 he left France, and went into Poland to gett acquaintance with the Brothers of the Rosie-cross: where he ended his daies". The reference to the Rosicrucians would be of interest if well-founded; but this whole statement bears the mark of unverified hearsay.

Willielmvs Davissonvs Nobilis Scotvs
Regis Poloniæ Protomedicvs

D. Schultz pin. *P. Lombart sculp.*

FRONTISPIECE

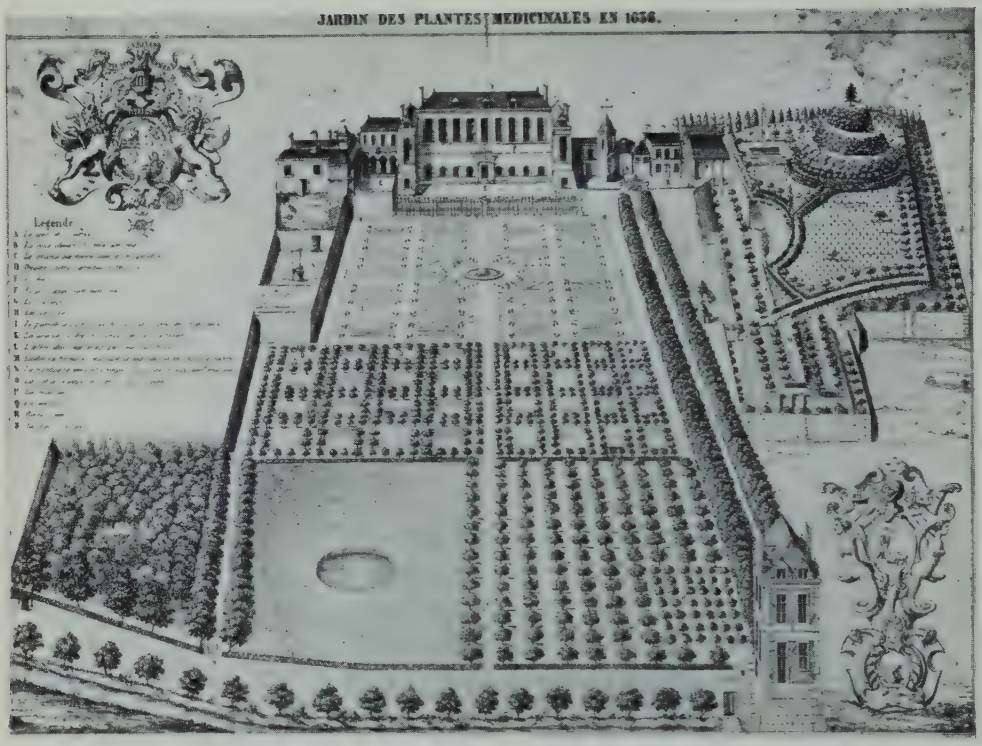

Fig. 1.—Jardin des plantes médicinales en 1636

From an engraving by F. Scalberge

Fig. 2.—La leçon de chimie au Jardin royal

From a drawing by Sébastien Leclerc, 1676

he was able to secure and maintain his position in this strongly Catholic court, aided by his easy command of Latin and French and his invariable suavity and tact. Besides being "senior archiatrus et chymicus" to King John Casimir and Queen Marie-Louise, he was keeper of the Royal Garden at the "Casimir Palace" in Warsaw. This Garden, no longer extant, was situated on the "Cracow Suburb", the most important street in Warsaw; the site was later occupied by the University.

Throughout this last epoch of his life Davidson was forced to abandon his favourite laboratory operations in chemistry for the practice of medicine. It was in the course of this Polish period that he produced at long last, in 1660, his massive commentary on Severinus. The dedication of this work throws some light on the disturbed conditions attending Davidson's later work, in a court constantly moving from place to place through a distracted country ravaged in the reign of John Casimir (1648–68) by a succession of wars more devastating than the gross and brutal Thirty Years' War[28].

"Begun on the banks of the Seine", writes Davidson, with a touch of nostalgia, "in the delightful Jardin du Roi at Paris, of which I was then curator and intendant, it grew in the midst of the North Sea waves, among the discomforts of journeys, the noise of armies, the rattle of drums, the clang of timbrels, the braying of trumpets, the roar of artillery, in short to the accompaniment of all manner of clashes of arms, added to pestilence, famine, and the never-ending harms of the sky and elements".

During the Swedish war Davidson accompanied Queen Marie-Louise. In 1659 he was at the court of Jerzy Lubomirski, marshal of the kingdom, and later he spent some time in Prince Buguslav Radziwill's court at Königsberg; but in 1667 he was again in "his lodging at the Royal Garden" in Warsaw. Among his patients in this period was Maria Kazimiera Sobieska; but unfortunately her husband, the famous Jan Sobieski, had no confidence in Davidson's medical ability.

Davidson's last publication was a polemical work in which he contested the opinion that a condition of the scalp known as Plica Polonica was a specific disease peculiar to Poland. This book was published at Dantzig in 1668, under the Paracelsian pseudonym of Theophrastus Scotus[29]. Very appropriately the

[28] Sienkiewicz gives a vivid picture of the condition of Poland at this time, in his historical novel, *The Deluge*.

[29] Theophrasti Verdici Scoti Doctoris medici Plicomastix seu Plicæ numero morborum A *'πόσπασμα* Typis Universitatis Abredoniensis in Scotia impressus Nunc veró Dantisci cum amplissimo Ser. Sac. Reg. Majestatis Privilegio venditur per Jacobum Pufflerum Seneriss. Reg. Majestatis Bibliopolam Anno M.DC.LXVIII.

This book contains an index to the work by Severinus and the *Commentariorum*, mentioned above. It was Davidson's last work, apart from the posthumous *Collectanea Chimica Medico-Philosophica Polonica*, Antwerp, 1698.

final token published in his life-time of the activities and interests of this remarkable man was printed at Aberdeen, which Davidson appears to have visited when the death of his patroness, Queen Marie-Louise, in 1667, compelled him to set his affairs in order and leave Poland. Early in 1669 Davidson went once more to Paris, where he is said to have died soon afterwards.

Philosophia Pyrotechnica

Davidson's earliest and most important work takes its place among the early textbooks of chemistry. Written in the first instance for the convenience of students and others who attended his lectures, this Latin text was issued in four parts, which were originally printed at Paris in 1633–35. The book (Fig. 3) bore the title *Philosophia Pyrotechnica sev Cvrricvlvs Chymiatricvs* ("Pyrotechnic Philosophy, or a Course in Spagyric Chemistry"). In later Latin editions "Cvrricvlvs" was changed to "Cvrsvs". A French edition translated by Jean Hellot was issued at Paris in 1651 and again in 1657.

The bibliography of this book is confused, owing to its divisions bearing different dates and also to variations of arrangement[30]. Hamy is wrong in denying the existence of any issue before 1640: that the first and second parts were published in 1635, together with the original version of the third and fourth parts, printed in 1633 (Fig. 4), is shown by copies in the Aberdeen and St. Andrews collections[31].

[30] Lenglet Dufresnoy, *Histoire de la Philosophie Hermétique*, 3 vols., Paris, 1742, **3**, 3, notes editions of 1635 and 1641; J. Ferguson (*op. cit.*, **1**, 201), quotes 1633–35, 1640–42, 1641, 1646 and 1657 as the dates of editions of *Philosophia Pyrotechnica*.

[31] See Hamy, *op. cit.*, pp. 10, 26.

The St. Andrews copy of *Philosophia Pyrotechnica* mentioned in the text has a first part, pp. 1–14, and a second part, pp. 15–393; p. 393 ends "Finish Secundæ Partis". These two parts have a common title-page dated Paris 1635. The third and fourth parts have separate title-pages dated Paris 1640 in each case, and agree with the details given by Hamy (*op. cit.*, p. 25). The first part of the 1635 edition is dedicated to James Stuart, Duke of Lennox, and the second part to George and Ludovic Stuart. In the 1640 edition (and also in a 1641 edition) of the first two parts, these parts are collectively dedicated to James Stuart and his four brothers, George, Ludovic, John and Bernard Stuart. The second part of the 1640 edition, as stated by Hamy, ends at p. 487. The second part of the 1635 edition does not correspond with the opening section of the longer second part of the 1640 edition. Interposed between pp. 208 and 209 of this part in the 1635 edition there is a section of 24 unnumbered pages preceding a folding geometrical design to which it relates. In the 1640 edition all the pages are numbered.

The Aberdeen copy mentioned in the text is identical with the St. Andrews one in so far as the first two parts (1635) are concerned. The third and fourth parts, however, are different, the title-page of each being dated 1633, without any mention of Bessin as publisher. The third part of 1633 is distinct from that of 1640, although the contents are sensibly the same. The fourth part of 1633 differs a good deal from that of 1640, in which the numbered

continued on opposite page

In the forefront of the first and other Latin editions of the complete book appears a beautifully executed "Emblema Totius Operis", or Emblem of the Whole Work, indicative of the author's leaning towards alchemical mysticism and symbolism. In the background (Fig. 5) Sol and Luna of the alchemists look down upon Cupid, Psyche and Proteus, seated amidst the plant, animal and mineral creations. The prominence given to these embodiments of Intellect, Soul, and Form—which proceed according to an adjoining inscription[32] from a common fatherland and heavenly origin—finds many echoes in the text of the work.

Chemistry is viewed as the Art of Fire, and this allegorical drawing shows the soul (Psyche) working through the intellect or intelligence (Cupid) and bringing fire, the chief agent of alchemy, to Proteus. Being in his human shape, Proteus will give true answers to this bearer of fire; and so the intelligent experimenter may discover how to carry out the Great Work of achieving the Stone. Tears stream down from the eyes of Proteus upon the alchemical fire, thereby symbolizing the conjunction of fire and water, the opposed elements of

[32] "Est eadem nobis patria et Coelestis origo": possibly an echo of Virgil's "Igneus est ollis uigor et caelestis origo" (*Aeneid*, vi. 730), indicating that the immortal "seeds" in men have a potency of fire and a heavenly origin.

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[31] *continued*

pages are increased from 178 to 272. In the third part of 1633, following the dedication to Henry Percy, and preceding the 42 numbered pages, there are 17 pp. (unnumbered) headed: "Avthoris ad cvriosam iuuentutem Philosophiæ & Medicinæ Pyrotechnicæ studiosam Parænesis". In the 1640 edition this has been transferred from the third to the fourth part, in which it follows the dedication to Gaumin.

In the Aberdeen copy 1635 (1633), as also in the St. Andrews copy 1635 (1640), the only "Priuilege du Roy" appears at the beginning of the first part (1635), and is dated 5 February, 1635. Both Aberdeen and St. Andrews possess an edition 1641 (1640), and Aberdeen has also a copy dated 1642 (1640).

The Ferguson Collection, in the Library of the University of Glasgow, possesses an exceptional copy in which the third and fourth parts of 1633, mentioned above, are bound together in a volume with an opening title-page bearing at the foot the wording: "Parisiis. Svmptibvs Avthoris. M.DC.XXXIIII. Cum Privilegio Regio". The privilege is not quoted. The volume is dedicated to Henry Percy. The title is: "Cvrricvlvs Chymiatricvs nobilissima illa et exoptatissima Philosophiæ & Medicinæ parte pyrotechnica instructus". The author is given as "Willielmo d'Avissono Scoto, Doctore Medico".

This initial form of the book, which Davidson appears to have published privately for the use of his students, is the most succinct and intelligible of all the editions, since it deals almost entirely with practical operations and individual preparations.

PHILOSOPHIA PYROTECHNICA,

WILLIELMI D'AVISSONI
Scoti Doctoris Medici.

SEV

CVRRICVLVS CHYMIATRICVS
nobilissima illa & exoptatissima Medicinæ parte pyrotechnica instructus.

Multis iisque haud vulgaribus obseruationibus adornatus, & ab ipsis primis Physicæ Theoreticæ & Practicæ Elementis inexpugnabili demonstratione illustratus, artificiosam nouamque rerum naturalium speculationem, & in vsus medicos præparationem, & administrationem, in se continens; in quo, adminiculo διακρίσεως aut συγκρίσεως Chymicæ ex Veget. Animal. & Mineral. familia petitæ, veræ & legittimæ rerum causæ deprehenduntur, ipsa αὐτοψία demonstrantur, cum recentiorum tum veterum omnium Philosophorum authoritate confirmantur: hactenus ab omnibus huius sæculi Chymicis, a tm simili studij genere sese exercentibus desideratus: nunc autem solidis & inconcussis radicibus stabilitus, assiduo studio & longa rerum praxi exaratus.

***

PARISIIS.
Apud IOANNEM BESSIN, propè Collegium Remense.

M. DC. XXXV.
Cum Priuilegio Regio, & Approbatione.

FIG. 3.—Title-page of *Philosophia Pyrotechnica*, Paris, 1635

The rule at the foot measures 6.3 *cm. in the original, in the St. Andrews Collection*

PARS TERTIA CVRRICVLI CHYMICI DE VOCABVLIS

CHYMICÆ OPERATIONI inseruientibus.

Ex curriculo W. D. Doctoris Med. in vsum auditorum suorum excerpta.

PARISIIS.

M. DC. XXXIII.

FIG. 4.—Title-page of the third part of *Philosophia Pyrotechnica, Paris*, 1633

The rule at the foot measures 6.9 *cm. in the original, in the University Library, Aberdeen*

JOHN READ

FIG. 5.—Emblem, with Davidson's coat of arms and motto, from *Philosophia Pyrotechnica*, Paris, 1635

The original engraving is 8.2 cm. wide

LES

ELEMENS

DE LA PHILOSOPHIE

de l'Art du Feu ou Chemie.

Contenans les plus belles obſeruations qui ſe rencontrent dans la reſolution, preparation, & exhibition des Vegetaux, Animaux, & Mineraux, & les remedes contre toutes les maladies du corps humain, comme auſſi la Metallique, appliquée a la Theorie, par vne verité fondée ſur vne neceſſité Geometrique, & démonſtrée à la maniere d'Euclides.

Oeuure nouueau, & tres-neceſſaire à tous ceux qui ſe propoſent ietter de bons fondemens pour apprendre la Philoſophie, Medecine, Chirurgie, & Pharmacie.

Traduit du Latin du ſieur Dauiſſone, Eſcuyer, Conſeiller, Medecin du Roy, & Intendant de la Maiſon & Iardin Royal des Plantes Medicinales, au Fauxbourg S. Victor, à Paris.

Par IEAN HELLOT, Maiſtre Chirurgien à Paris.

SECONDE EDITION.

A PARIS,
Chez IEAN PIOT, Libraire Iuré, ruë S. Iacques, au S. Eſprit, & à la Salamandre d'Argent.

M. DC. LVII.
Auec Priuilege du Roy.

FIG. 6.—Title-page of *Les Elemens de la Philosophie de l'Art du Feu ou Chemie*, 2nd edn., Paris, 1657

The rule at the foot measures 7.5 cm. in the original, in the St. Andrews collection

alchemy, in the accomplishment of alchemy's central task. An attached Latin verse runs as follows, in translation:

> Woe is me, with how great cares am I, Cynthia [the moon] torn!
> I burn, and alas, moisture flows from my fire.
> I am both Nile and Etna; put out the fire,
> Ye tears! Flame, drink up my tears!

Davidson made a point of dedicating his works to potentially useful patrons and he apportions the four parts of the *Philosophia Pyrotechnica* of 1635–40 to no fewer than five exalted personages, these being, in order: James Stuart, Duke of Lennox and Baron of St. Andrews; George and Ludovic, brothers of the Duke; Henry Percy, son of the Earl of Northumberland; and Gilbert Gaumin, Councillor of the King of France.

"L'Art Du Feu Ou Chemie"

The French version, entitled *Les Elemens de la Philosophie de l'Art du Feu ou Chemie* (Fig. 6), differs very much from the earlier Latin one. It lacks the engraved emblem; the theory has been pruned; the practical matter has been amplified and brought up to date; the whole work has been rearranged. In short, the French text can be regarded only nominally as a translation of the earlier Latin version. It is the only work of Davidson written in any language other than Latin. In considering the nature of Davidson's view of chemistry it is advantageous to deal with his revised treatment of *Philosophia Pyrotechnica* appearing in the French text of 1651 or 1657. The chief difference between these two French issues[33] lies in a dedication to John Casimir, King of Poland, which is included only in the first of them.

In this dedication Davidson points out that the book is devoted to the art of an agent that has enabled man to probe ever deeper into the secrets of nature: without fire, our knowledge of natural things would be very imperfect. The sub-title states that the book deals with the preparation of medicinal remedies from vegetable, animal and mineral sources, including metals, and that the underlying theory is founded upon geometrical principles and demonstrated after the manner of Euclid. The work is recommended to students of philosophy, medicine, surgery and pharmacy. The author is described on the title-page as the "Sieur Davissone, Escuyer, Conseiller, Medecin du Roy, & Intendant

[33] The French edition of *Les Elemens de la Philosophie de l'Art du Feu ou Chemie*, Paris, 1657, is composed of the same printed sheets as that of 1651, with a new title-page and a minor alteration at the beginning. There is no ground for Dufresnoy's statement that another French version was published in 1675. There is a copy of the 1651 edition in the University Library, Aberdeen, and of the 1657 edition in the St. Andrews Collection.

de la Maison & Jardin Royal des Plants Medicinales, au Fauxbourg S. Victor, à Paris".

The book opens, after a pleasant custom of that age, with a "Sonnet sur ses Oeuures Chemiques, à Monsieur Davissone", greeting the author as:

Toy par qui tant de fleurs, & tant de Minereaux
Dépoüillent à ton gré leurs qualitez contraires,
Qui puisses la santé dans la source des maux
Et par qui les poisons deuiennent salutaires.

This is followed by some still more flattering verses from a second poet, working up to a grand climax:

Et beaucoup au dessous d'vn œuure si parfaict:
Grand Dauisson ta recompense
N'est pas bornée dans la France,
Dans Europe ou dans l'vniuers,
Ce Dieu qui t'a donné de le si bien connoistre
Par tous ses secrets découuerts
Te fera dans le Ciel comme vn astre paroistre.

The first part of the French version discusses the name, origin and nature of the Philosophy of the Art of Fire, or Chemistry. This is defined as a scientific art, ordained by God, which deals with the resolution of mixtures into their elementary constituents and recognizes that the power of nature resides in the balm and seminal virtues of vegetables, animals and minerals. The application of this art in the preparation of medicines constitutes the true practice of medicine.

Chemical History

Davidson derives the name of the science from the ancient name of Egypt, "Chemie", the land of Ham, one of the sons of Noah. He links this so-called Hermetic Art also with the name of Hermes Trismegistos[34], who, according to Davidson, was called the Thrice-Great because of his profound knowledge of vegetable, animal and mineral substances. A special knowledge of chemistry is ascribed, among others, to Tubal-Cain and Moses; it is clear, says Davidson, that Moses could not have turned the Golden Calf into potable gold without a deep knowledge of chemistry[35].

In the course of a historical review which is for the most part uncritical and credulous Davidson makes a special mention of Paracelsus, who, he says, introduced a new system of medicine apparently contradictory to that of Galen, but in reality forming an extension of it. Medicine owed much to Paracelsus, because he added mineral remedies to those derived from vegetables and animals.

[34] See J. Read, *Prelude to Chemistry*, London, 1939, 4, 54.
[35] See *Humour and Humanism in Chemistry*, p. 4.

Paracelsus encountered violent opposition from the ignorant physicians of his time; but now, thanks to God, the present age begins to see more clearly and to appreciate doctors who are skilled in chemistry as well as in the Galenic system. Here Davidson speaks with approval of M. de la Rivière, who in spite of early opposition turned later in his medical career to the study of chemistry, thereby becoming the first physician of his day.

Definitions and Practical Methods

The short second part of *Les Elemens* explains the meaning of common chemical terms used in the practical part, such as cohobation, calcination, precipitation, distillation, and many others.

Intermingled with much theoretical matter, and interrupted by numerous lengthy digressions, the third and chief part of the book contains general remarks on the practical methods of breaking down vegetable and animal materials, largely by destructive distillation, effected by fire, into their imagined elements and principles[36]. The chief practical interest of the work lies in the many descriptions of specific preparations made from vegetable, animal and mineral sources, and in their medicinal applications. The rudimentary attempts at classifying the products under such names as spirits, oils, dyes, balsams, magisteries, flowers, salts and strong waters are reminiscent of Beguin in his *Tyrocinium Chymicum*, and so are the practical details of individual preparations. It is instructive to make a few illustrative selections from part of *Les Elemens*.

Salt of Tartar

Salt of tartar [potassium carbonate] is made by the dry distillation of crude tartar [argol], the residue being calcined and crystallized until completely decolorized. Davidson distinguishes between the volatile oil of tartar and the deliquesced salt of tartar also known as oil of tartar. The former is inflammable, and although not to be taken internally it is a good remedy for hysterics when its very unpleasant vapour is inhaled. In a typical digression the author then indulges in a lengthy and diffuse dissertation on the nature of flame and inflammability. Flame is elementary and originates from an ethereal, shining and vivifying flame of heavenly origin. Varying quantities of an inflammable sulphur are present in vegetables, animals and minerals.

Flowers of Benjamin

Flowers of benjamin [benzoic acid] are mentioned as a remedy for disease of the lungs and for asthmatic complaints, although they are not considered to be so good as flowers of sulphur. The flowers are obtained by sublimation

[36] For contemporary ideas on the nature of these elements and principles, see *Humour and Humanism in Chemistry*, pp. 104, 126.

from gum benzoin and storax, which are described as fragrant exudations from certain Indian trees. Although the storax tree flourishes in the Jardin Royal at Paris, it is unable to produce the exudation owing to lack of heat.

Corrosive Sublimate

In observations on corrosive sublimate Davidson affirms the untenable thesis that since the simple bodies that compose the sublimate are harmless it follows that the sublimate itself is not poisonous. In the course of an attached argument, lengthy and largely irrelevant, he introduces a reference to the cubic, dodecahedral and tetrahedral forms of a remarkable series of sixty-three gall-stones coming under his notice in the year 1643.

By boiling sanicle, comfrey, or some other vulnerary with water, dissolving corrosive sublimate in the distillate, and adding lime-water, Davidson states that a filtrate may be obtained of extraordinary potency in the treatment of gangrene and malignant ulcers. He advises physicians to use this water to the glory of God and the consolation of His creatures, since its like has not been seen among men since the creation.

Strong Waters

As already mentioned, Davidson's preparative methods are in general very similar to Beguin's. Thus, under the heading of "strong waters", it is stated that aqua fortis ("l'eau forte") is made by distilling a mixture of saltpetre and and calcined vitriol. When this product is distilled with powdered sal ammoniac from an ash-bath it yields aqua regia: "Si vous en voulez faire de l'eau regale, vous prendrez 4. onces de ceste eau que mettrez dãs vne retorte de verre sur les cẽdres auecvne once de sel Armoniac en poudre, & le distillerez sur les cẽdres chaudes & ferez vne eau regalle".

Davidson does not recognize these "strong waters" as acids. In discussing their solvent action he remarks that aqua fortis dissolves only feminine metals and marcasites, like silver and bismuth; whilst aqua regia dissolves only masculine ones, like gold and antimony. Quicksilver, however, which is both masculine and feminine, is dissolved by both of these "strong waters".

In the course of some extended observations on "strong waters", Davidson refers to the striking nature of solvent action, whereby a heavy metal like quicksilver is entirely corroded and upheld in its own weight of good aqua fortis, the tendency of the heavy metal to sink to the bottom being overcome. He seeks an explanation by postulating that all bodies tend to orientate themselves towards three centres: that of the universe, which may be the sun; that of all corporeal things, which is the centre of the earth; and a third centre peculiar to each individual body. This idea is discussed at length with a vagueness and lack of precision which permeate the theoretical sections of the treatise.

Common Salt

Davidson took a liberal view of the nature of salts. A salt, he says, is a fixed water partaking of the nature of fire; just as water is a volatile salt partaking of the nature of air. His contemporary, Glauber, was obsessed with the importance of salts and particularly with the unending virtues of the celebrated Glauber's salt [sodium sulphate]. Davidson was equally enthusiastic about the virtues of common salt and various preparations derived from it. He mentions the preparation of spirit of salt [hydrochloric acid] by heating salt with clay, powdered brick, or alum. He points out that dropping water on to molten salt may also be used, although it is difficult to design a sufficiently resistant apparatus for the purpose.

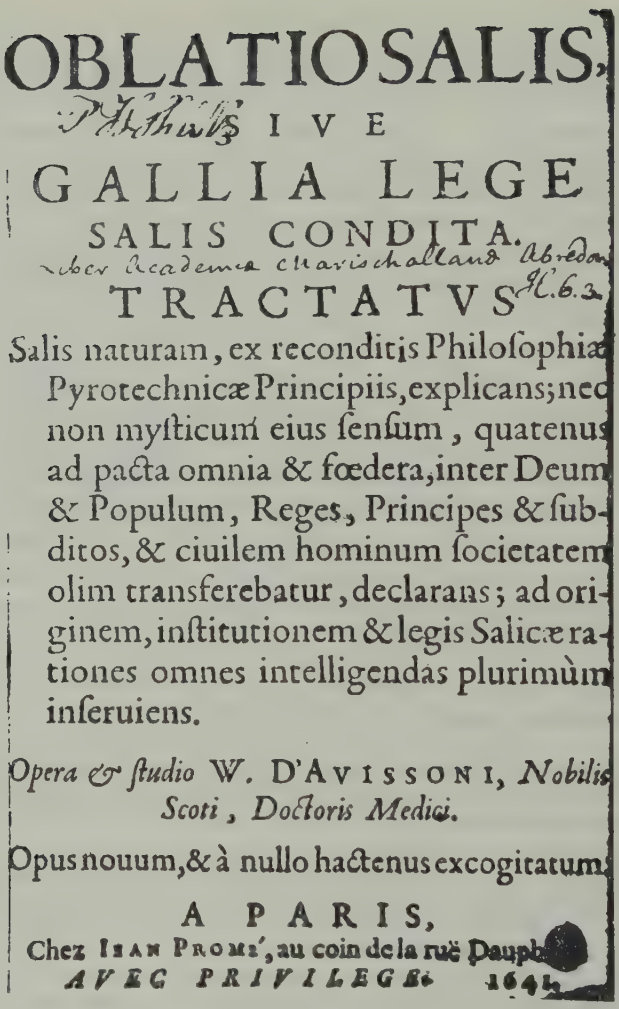
In commending Glauber's recent improvement of this process, Davidson shows that he is aware of current advances in chemical practice, since it was only in 1648 that Glauber published his method of heating moistened salt in a charcoal furnace[37]. Some ten years later this great German chemist first obtained spirit of salt by the classical method of distilling salt with oil of vitriol and absorbing the vapour in water. Davidson gives many medicinal applications of spirit of salt, and refers his readers for further information on remedies derived from salt to the works of Glauber, Croll, Hartmann, Beguin, and Georg and Johann Agricola[38].

[37] Glauber's method of preparing spirit of salt from moistened common salt was given as follows: "Dissolve salt in common water, then quench burning coales in this water, that they may be impregnated with the salt, which afterwards set on fire in the furnace: but you must first cast in other burning coals, upon which you must cast in those that are impregnated with salt untill the furnace be full, as is above said: and whiles the coales burn the salt is resolved by the force of the fire into spirit.

"Now you must observe that he that distils spirit of salt after this manner must make choice of glass receivers, because the spirit whilest it is hot, penetrates by reason of its wonderful subtilty, those that are earthen" (J. R. Glauber, *A Description of new Philosophical Furnaces*, trans. J.F.[rench], London, 1651, 10).

[38] Glauber's *Furni novi Philosophici* was first published in 1648; Crollius (d. 1609) was an adherent of Paracelsus; Beguin's *Tyrocinium Chymicum* (*v. supra*) must have been very familiar to Davidson; Georg Agricola gave a full account of the manufacture of common salt in *De .Re Metallica* (1556); Johann Agricola was a follower of Paracelsus who wrote a commentary (1638) on Poppius's *Chymische Medicin* (1617). Johann Hartmann, as mentioned in the text, lectured on iatro-chemistry at Marburg.

In the St. Andrews collection there is a copy of a work published at Geneva in 1647 under the title, "Iohannis Hartmanni medicinæ doctoris et qvondam Chymiatriæ in Academia Marpurgensi Professoris celeberrimi, Principúmque Hassiæ Archiatri PRAXIS CHYMIATRICA Edita à Johanne Michaelis, Philosophiæ & Medicinæ Doctore, & Professore ibidem extraordinario: & Georgio Euerhardo Hartmanno Authoris Filio". To this are appended three other tracts. The first edition of this work was published at Leipzig in 1633, two years after Johann Hartmann's death.



OBLATIO SALIS,
SIVE
GALLIA LEGE
SALIS CONDITA.
TRACTATVS
Salis naturam, ex reconditis Philoſophiæ Pyrotechnicæ Principiis, explicans; nec non myſticum eius ſenſum, quatenus ad pacta omnia & fœdera, inter Deum & Populum, Reges, Principes & ſubditos, & ciuilem hominum ſocietatem olim transferebatur, declarans; ad originem, inſtitutionem & legis Salicæ rationes omnes intelligendas plurimùm inſeruiens.
Opera & ſtudio W. D'AVISSONI, *Nobilis Scoti, Doctoris Medici.*
Opus nouum, & à nullo hactenus excogitatum.
A PARIS,
Chez ISAAC PROMÉ, au coin de la ruë Daup
AVEC PRIVILEGE. 1641.

FIG. 7.—Title-page of *Oblatio Salis*, Paris, 1641
The fourth line from the foot measures 9.5 cm. in the original, in the University Library, Aberdeen

THE LAW OF SALT

Salt became an obsession with Davidson. In 1641 he published, at Paris, a slim book of 130 pages with the startling title, *Oblatio Salis sive Gallia lege Salis condita Tractatus* ("The Oblation of Salt, or France preserved by the Law of Salt"). This curious work (Fig. 7) illustrates Davidson's mystical leanings,

besides serving as an example of various hobby horses which he rode with a free rein. The book sets out to "explain the nature of salt on the basis of obscure principles of pyrotechnic philosophy, also its secret meaning, showing how it was formerly used metaphorically of all contracts and agreements between God and His people, kings and princes and their subjects, and the civil society of mankind in general; highly useful for the understanding of the origin of customs and all matters pertaining to the Salic Law. A new work, hitherto unthought of by anyone".

Davidson attached so much importance to this treatise that he dedicated it to the great statesman, Cardinal Richelieu. The theme filled his mind to such a degree that when dealing with spirit of salt in *Les Elemens* he turned aside to indulge in a long discussion upon this so-called Law of Salt. Quoting various references to salt in the Old Testament, he points out that "the Lord God of Israel gave the kingdom over Israel to David for ever, even to him and to his sons by a covenant of salt"[39].

"Semblablement", he remarks, "Dieu ayant esgard à la stabilité, & permanence du sel qui ne se laisse pas corrompre, ny par le feu, ny par l'eau, a voulu choisir cét estre par dessus tous les autres, comme vn symbole ou marque de grace, permanence, & stabilité des promesses & dons qu'il faisoit à son peuple".

To this source Davidson assigns the origin of the Salic Law—"la plus belle Loy de l'Estat", as he calls it. He suggests further that the word *Salic* was derived from two old Germanic words, *sal* and *lik*, meaning "salt-like." In view of the great importance of the Salic Law to France, Davidson takes pride in being able to render this good service of disclosing its origin to a people amongst who he has lived for thirty-three years, with such satisfaction that these years have seemed only days. He then refers to the particularly strong bonds that have existed for centuries between France and Scotland, and at last returns to his chemical theme with the parting hope that his adopted country may endure with a stability rivalling even that of salt.

Fulminating Gold

Fulminating gold was obtained by Davidson as a yellow precipitate, on dissolving the metal in aqua regia and adding potassium carbonate ("huile de tartre"): "si vous en mettez deux ou trois grains dans vne cuillier d'argent, auec vne chandelle allumée par dessous, vostre poudre fera du bruit comme vn coup de cannon, d'ou il est appellé or fulminant". In his observations on this explosive property, Davidson points out that in gunpowder it is the nitre that furnishes the wind and expansion, sulphur that gives the flame, and charcoal

[39] *II Chronicles*, xiii, 5. There is a copy of *Oblatio Salis*, Paris, 1641, in the University Library, Aberdeen.

that supplies the corporeal material creating the report; similar rôles are played in fulminating gold by the nitre of aqua regia, the sulphur of gold, and the salt of tartar.

Nitre

In talking about nitre he remarks that he knows of no other natural or artificial substance in such common use of which the character is less known. The sky, the earth, the oceans, foodstuffs, plants, wine, cider, beer, all abound in it. The common assumption that nitre is inflammable is wrong; no substance is less so. Flame is produced only when a combustible material comes into contact with the nitre. The substance of nitre has a twofold nature, corporeal and incorporeal. Davidson develops this last idea in a characteristic disquisition of great length and nebulosity, in which he quotes several poets and invokes the authority of Aristotle, Hippocrates, Hermes Trismegistos, Virgil, Ovid, Pliny, Geber, the Cabbalists, Plato, Job, and others.

The Nature of Metals

In discussing the nature of metals, Davidson refers to Sendivogius's *Tractatus de Sulphure*[40] and expounds the sulphur-mercury theory of mediaeval alchemy. For the generation of metals two seeds or sulphurs are necessary, these being masculine and feminine. In the words of the *Speculum Alchemiae*, ascribed to Roger Bacon by a pseudepigraphic mediaeval writer[41]: "All mettalls and minerals . . . are begotten of these two: but I must tel you, that nature alwaies intendeth and striveth to the perfection of Gold: but many accidents coming between, change the mettalls . . . for according to the puritie and impuritie of the two aforesaid principles . . . pure and impure [noble and base] mettalls are ingendred". The sulphur and mercury of this theory were not the common substances bearing these names: the terms represented combinations of properties or qualities, notably inflammability and metallicity, respectively.

That metals are transmutable, says Davidson, is shown by the conversion of iron into copper, which may be observed when one adds iron filings to a solution of vitriol of Venus [copper sulphate]. Some believe, he comments, that this operation was one of the secrets of Pythagoras of which Ovid speaks

[40] *Humour and Humanism in Chemistry*, p. 57. Professor T. Estreicher of Cracow University has pointed out that Sendivogius' anagram *Divi Leschi genus amo* (*loc. cit.*) must be interpreted as "I love the Poles" (or the descendants of Lech), since Lech (or Leszek) was the legendary founder of the kingdom of Poland. From this anagram also it is clear that Sendivogius was a Pole and not a Moravian as sometimes stated; his name points to the same conclusion, since it is a Latinized form of a Polish name (meaning, literally, "he who judges warriors").

[41] *Prelude to Chemistry*, p. 24.

in his Metamorphoses, and that the conversion has been recorded hieroglyphically in the amours of Mars, Venus and Vulcan.

Precious Stones

A long disquisition on precious stones contains allusions to Aaron's vestments, the twelve tribes of Israel, the Apocalypse, and other biblical references. The diamond is held to be produced from water by long coction under solar influence. Its virtues are many, including the protection it affords to its possessor against sorcery, enchantment, poison, plague, incubus, succubus, fear and melancholy.

Strife Over Antimony

As an admirer and exponent of the Paracelsian system, Davidson naturally took a great interest in antimonial preparations and their medicinal applications, to which subject he devoted a good deal of space. Paracelsus's advocacy of such remedies had been given additional impetus at the opening of the 17th century by the appearance of a remarkable work entitled *The Triumphal Chariot of Antimony*, which ran through many editions in various languages during the course of the century. Written by a pseudonymous Basil Valentine[42], or "Mighty King" of alchemy, it extolled the virtues of antimony, which the writer claimed as "one of the seven wonders of the world." No one before him, asserted Basilius, had "any real acquaintance with its potency, virtues, powers, operation, and efficiency. If any person could be found, he would be worthy to be drawn about in a triumphal car, like great kings and warriors after mighty and heroic achievements in the battlefield. But I am afraid", he added, with biting sarcasm, "that not many of our Doctors are in danger of being forcibly placed in such a car".

In much the same vein Davidson trounches those slothful and malicious physicians, as he calls them, who are impervious to the march of progress in medicine and who exude an influence much more poisonous than that which they impute to antimony, particularly in striving to divert young medical aspirants from the study of chemistry. By neglecting such miraculous remedies these reactionaries seek to override the experience of more than a century.

Turning from such despicable practitioners, he proceeds to lavish high praise upon Messieurs de la Violette and de Mayerne, formerly physicians to the King of France. He points out that Turquet de Mayerne's reputation for marvellous cures was such that he received a royal call to England, where he rendered great services to King James and King Charles, serving the latter

[42] *Prelude to Chemistry*, p. 189.

until his death [1649], and with such success that he received the honour of knighthood and attained an income of nearly a hundred thousand livres.

Mayerne[43] had come to France from Switzerland, the country of Paracelsus himself, and had held the appointment of physician to Henri IV. Because of his strong advocacy of chemical medicines, and also on account of his religious heresy, he was ostracized by the Paris College of Physicians in 1603. Later he reached great eminence in England, where he remained from 1611 until his death in 1665.

The facilities provided by the lectures and laboratories of the Jardin du Roi for the study of botany and chemistry were due in large measure to the exertions of a coterie of physicians, including men like Mayerne, who were mostly Protestants and who had received their medical training in Switzerland, in Germany, or at Montpellier. It is not surprising that friction should develop between a band of physicians of this alien type and the members of the very conservative medical faculty of the University of Paris. The resulting intolerances and quarrels may be traced in Davidson's writings, in which he made a vain attempt to placate the reactionaries by trying to blend the intrusive Paracelsian ideas with the established Galenic order.

There is no doubt that the unrestrained use of antimonial, mercurial, and other mineral medicines caused much mischief at this time; but Davidson was indefatigable in his defence of such remedies. After holding up Mayerne as an example to be emulated, he passes on to rebut in detail various contemporary publications attacking the supposed medicinal virtues of antimonial preparations. "When I am told", he writes in a vehement denial of the fifth of ten specific allegations, "that Pliny and Dioscorides were opponents of antimony, I reply that one of them seems to have been as great a liar as the other when he says that mercury evaporates upwards. It is evident that he had never practised in his life: for mercury prepared and administered in small single doses purges downwards more gently than senna". He ends by advising those physicians who are ignorant of chemistry to keep their mouths shut. There is nothing more ridiculous, he says, than a man who talks about something he does not understand. One must know something about chemistry before starting to decry it.

Theory and Fantasy

It is in his purely theoretical and speculative discussions, which are strongly tinged with mysticism, that Davidson demonstrates to the full his tendency to become prolix, nebulous and repetitive. In a long introduction to the third part of *Les Elemens*, and also in a discussion of "Physique speculative" in the

[43] See A. C. Wootton, *Chronicles of Pharmacy*, 2 vols., London, 1910, **1**, 145.

fourth part, he stresses the importance of the three Paracelsian principles, sulphur, mercury and salt, behind which lurk the four elements of Aristotle. Vegetables, animals and minerals all have their own varieties of sulphur, mercury and salt. All these basic constituents of matter were created by God in the beginning. Great play is made with such terms as subtle and gross, fixed and volatile, corporeal and incorporeal, and there are frequent indulgences in metaphysical speculation. Shining through the mist of these ideas, one discerns the Neoplatonic conception that the whole cosmos owes its existence to a divine emanation proceeding from the Creator through the hierarchies of angels and stars to the earth and the microcosm of man's body.

Like Agrippa von Nettesheim, Davidson refers repeatedly to Plato's *Timaeus*. In the words of Agrippa[44], reflecting earlier views of Dante, he holds that "God is the end and beginning of all Virtues. He gives the seal of the Ideas to his servants, the Intelligences. . . . The Form therefore and Virtue of things comes first from the Ideas, then from the ruling and governing Intelligences, then from the aspects of the Heavens disposing, and lastly from the temper of the Elements disposed, answering the influences of the Heavens, by which the Elements themselves are ordered or disposed. . . . Every virtue of herbs, stones, metals, animals, words and speeches, and all things that are of God, is placed there".

Again, like Count Michael Maier, the musical alchemist of Prague[45], Davidson does not hesitate to call upon classical mythology from time to time in order to reinforce his theoretical arguments. Thus, the fable of Apollo and Daphne is put forward as a hieroglyphic representation showing how certain virtues and influences borne by the rays of the sun pursue and react with a universal humidity surrounding and penetrating the earth. The resulting green plants, including the laurel bush into which Daphne was transmuted, obtain nourishment from minerals and provide it for animals. In this way the ancient fable serves to link together the fundamental trinity of vegetables, animals and minerals to which Davidson is so fond of alluding.

A Geometrical "Multum in Parvo"

Davidson was evidently of a mathematical cast of mind, and he loses no opportunity of stressing the Pythagorean and Platonic conceptions of the significance of number, proportion and geometrical form in the interpretation of Nature and the universe. Towards the end of his book he attempts to frame a graphic synthesis of his ideas in a complicated geometrical figure (Fig. 8), akin

[44] See H. C. Agrippa von Nettesheim, *De occulta philosophia*, Antwerp, 1531, and the English translation edited by W. F. Whitehead, Chicago, 1898.

[45] *Prelude to Chemistry*, p. 234 *et seq.*

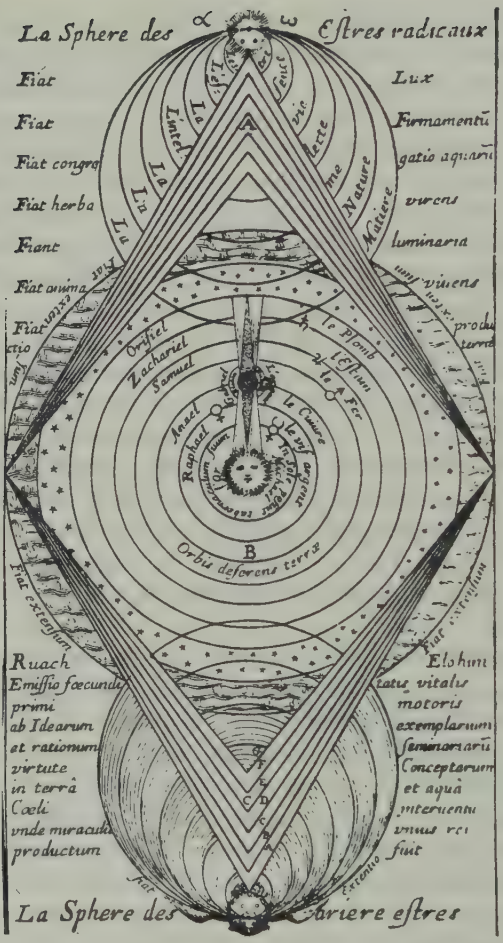


FIG. 8.—Diagram from *Les Elemens de la Philosophie de l'Art du Feu ou Chemie*, Paris, 1657

The original diagram is 9·9 cm. wide

to the many earlier diagrams of this type so characteristic of mediaeval ideas of the cosmos.[46] It would be a formidable task to explore in detail the intricacies of this diagram, or to enter into the still stranger geometry of its forerunner in the earlier Latin version of the book. It was in this complicated web of Platonic

[46] *Prelude to Chemistry*, pp. 83–85.

and Neoplatonic thought that Davidson lived and worked and had his being, and its tenets permeate the whole book.

According to "le diuin Platon", as Davidson calls him, Nature is based upon a mathematical plan. "Le nombre septenaire des Astres n'est-il pas harmonique & admirable?" asks Davidson. "Le nombre trois n'est-il pas mystique?" The numeral 4, he states, quoting the Pythagoreans, is characteristic of the body a of matter, whilst the numeral 3 is bound up with the soul and form. Accordingly Davidson begins and ends his diagram with the Platonic isopleth, and triangle having the numerical sequences 2, 4, 8 and 3, 9, 27 arranged respectively along two of its sides in conformity with this idea.

All created things have a threefold nature, and in the diagram the upper and lower series of seven circles represent causation and form, respectively; while the middle series, composed of the other two, represent participation. A subjacent table gives a list of seven other mystical groups of seven, one of which is composed of the four elements of Aristotle and the *tria prima* of Paracelsus.

The upper region of seven zones expands from Being through Essence, Life, Intellect, Soul and Nature to Matter, and this region has its reflex in a similar lower region of seven expanding zones. The middle region is reminiscent of Aristotle's idea of the universe as a series of concentric spheres or shells, and the arrangement is heliocentric in agreement with the Copernican system. In this region the seven metals and heavenly bodies are linked with seven angels or archangels. The sphere beyond those of the seven heavenly bodies represents the firmament of fixed stars, and the outermost sphere is that of the igneous waters above the firmament, corresponding to the *primum mobile* of Aristotle's scheme. It is noteworthy that in another part of the book Davidson mentions the ingenuous belief, held by some, that these igneous waters are the same as the marvellous quintessence of wine[47]. This idea, however bizarre it may seem, falls into line with the mediaeval belief that purified alcohol—so readily prepared from the vegetable creation after it has absorbed the vivifying influence of the sun—was a combination of fire with its inveterate enemy, water; some alchemists, indeed, saw in this blending of opposites, or squaring of the alchemical circle, the approaching end of the world.

[47] Davidson obtained the quintessence of wine by digesting wine over ignited salt of tartar (potassium carbonate) and then rectifying it from more of the salt.

"Beaucoup croyent que les eaux ignées", wrote Davidson, "qui sont dessus le firmament, ou bien ceste huile inextinguible, n'est autre chose que ceste quintessence, laquelle influë icy bas sur les choses sublunaires, allant & venant perpetuellement pour entretenir le commerce entre Dieu, & ses creatures: & que ceste quintessence fist ce feu de Moyse, enuoyé premierement du Ciel, & qui dura iusques à la cõstruction du Temple de Salomon" (*Les Elemens*, Paris, 1651 & 1657, 323).

Ubiquity of the Platonic Solids

Davidson showed no originality worthy of mention either in his speculative ideas or his practical operations; but as a *tour de force*, towards the end of *Les Elemens* he introduces a dissertation of more than thirty pages entitled: "Ouurage nouueau & sur lequel personne n'a encor ny trauillé ny écrit". This opens with a reference to the Pythagoreans, followed by an exposition of the Neoplatonic philosopher, Proclus. All things, avers Davidson, are created by weight, measure and order, and thus exist in a harmonious unity[48]. He makes great play with the five Platonic solids, consisting of the four-sided tetrahedron, the six-sided cube, the eight-sided octahedron, the twenty-sided icosahedron, and the twelve-sided dodecahedron. The first four of these were associated from very early times with the four elements of the physical world, fire, earth, water, and air; while the dodecahedron, discovered later, was held to represent the quintessence, or the universe.

From such ideas Davidson drew a series of extravagant and fanciful analogies, failing to realize in so doing that analogy throughout the ages has provided one of the chief sources of human error. For example, he points out that the dodecahedral pentagon incloses three isosceles triangles, which he proceeds to link in a mystical association with the three seminal principles of all things, salt, sulphur and mercury: these, he holds, possess both a celestial and terrestrial virtue. Moreover, three surfaces constitute a solid angle, and the twelve pentagons of the dodecahedron form four such groups, corresponding to the four elements. All corporeal nature is primarily composed of matter, form and proportion, from which spring the four elements and the three principles.

That is to say, the incorporeal nature of a body finds an expression in its corporeal form. This may seem to be a purely mystical or metaphysical idea; but before the man of science dismisses it as an idle dream, he should call to mind such modern scientific conceptions as isomorphism, enantiomorphism, and relationships between morphological characters and chemical constituents of plants[49]. The human imagination is not content to remain quiescent. In all ages it has roved restlessly hither and thither over the illimitable ocean of the unknown, now sounding profound depths, now reaching out to the remote confines of "faery lands forlorn". Its outpourings have often seemed untenable, fantastic, grotesque, to a later and more enlightened age. Nevertheless, in judging the thought of bygone generations, it is well to remember that inspired saying of William Blake: "Everything possible to be believ'd is an image of truth".

[48] *Prelude to Chemistry*, p.247.
[49] *Humour and Humanism in Chemistry*, p. 320.

The first of two plates illustrating this section of the book depicts the five Platonic solids, followed by a number of derived forms. The second plate[90] shows various natural illustrations of the argument, including crystals of common salt (*sal esculentum*), rock salt (*sal gemmae*), vitriol of Venus (*vitriolum aeris seu Veneris*), gypsum, Styrian nitre, "hexagonal snow" (*nix sexangularis*), and salt of hartshorn (*sal cornu Cerui*). Besides those of crystals, there are drawings of leaves of the fig and vine inclosed in pentagons; a bee imprisoned in a hexagon, suggestive of an adjoining section of a group of hexagonal bee-cells; and five-petalled flowers of the peach and dog-rose.

Below the leaves and the bees a Latin inscription states that "as a solid angle cannot be made without three planes, so a natural body cannot be made without salt, sulphur and mercury". Interspersed between the drawings of crystals there is a quotation from the *Wisdom of Solomon*, forming a succinct expression of Davidson's views: "Thou hast ordered all things in measure and number and weight".

"Are not many flowers and nearly all fruits of five parts", asks Davidson, "a number clearly derived from the dodecahedral pentagon?" He then proceeds to comment on the crystalline forms of minerals, "which many hold to be inanimate", mentioning in particular the geometrical shapes of the emerald, the diamond, and vitriols of Mars and Venus [sulphates of iron and copper]. In this section of the book, indeed, Davidson makes an early contribution to crystallography, although it must certainly be characterized as a very modest one.

Handicaps of *Philosophia Pyrotechnica*

In his note on *Philosophia Pyrotechnica*, Lenglet Dufresnoy wrote in 1742 that it had achieved only a moderate success, in spite of its appearance in French as well as in Latin. The reason is evident when the work is compared with the contemporary writings of Beguin, Glauber, le Febure and Glaser. These publications were not overburdened with the theoretical and metaphysical speculations that bulked so largely in Davidson's treatise. All these authors laid their main emphasis on the practical aspect of the subject; they arranged their matter intelligibly; and they provided an orderly list of contents with page references. More than this, they catered for an extensive public eager to buy an easily understandable home-doctor replete with efficacious remedies for all conceivable human ills and inconveniences.

Thus, at the end of Glauber's *Descriptions of New Philosophical Furnaces*, published at London in 1651, there is a general alphabetical index, followed by "An Alphabeticall Table of the Diseases and Infirmities for which Cures or

[90] Reproduced (plate 21) in *Humour and Humanism in Chemistry*.

Remedies are prescribed". Glauber's book enables the anxious enquirer to make instant reference to such subjects as : Beauty to continue to extream old age; Belly to loosen; Birds dead to raise to life; Face a paint for; Hystericall passions; Measles; Melancholy to purge; Youth to renew. His book gives remedies and recipes for these and scores of other equally urgent drawbacks and afflictions. Davidson attended to none of this. He disdained stooping to conquer a frivolous public. He left his readers to grope unguided through a maze of mingled speculation, theory, and practice. His book was too esoteric for the common taste. It was not only a sealed book; it was hermetically sealed. The original text was in Latin, and the single vernacular version appeared only after many years. As Hamy remarked, Davidson's Latin had a certain elegance, but it was obscure, diffuse, and crammed with quotations gathered from a mass of ill-digested learning. It is significant that *Philosophia Pyrotechnica*, unlike the corresponding publications of his contemporaries, was never translated into either German or English.

Davidson's Character

Many contemporary tributes were paid to Davidson's knowledge and skill, among them being that of his fellow-countryman, Sir Thomas Urquhart of Cromarty[51], who wrote: "The excellency of Dr. William Davidson in alchemy above all the men now living in the world, whereof by his wonderful experiments he giveth daily proof, although his learned books published in the Latin tongue did not evince it, meriteth well to have his name recorded in this place".

No detailed comment on his personality and character is known, but fortunately an excellent engraving (see the frontispiece) by P. Lombart after D. Schultz has survived, in which Davidson is depicted towards the end of his career[52]. The facial expression is marked by a grave sensitivity, the large eyes are full of intelligence and vivacity, the attire is neat and precise. Here is a man fully aware of his importance and standing in the world, alert and eager even in his old age, and animated by an inner spiritual fire. La Merolles commended his probity; others were less favourably impressed by his taciturnity. The characteristic Scots attributes of independence, ambition, and will to make one's own way in life were amply demonstrated in his career, to which—again like a true Scot—he attached so much importance.

In shaping that career he showed a stubborn resolution in overcoming

[51] Quoted by Small, *op. cit.*, **10**, 265.

[52] According to Hamy (*op. cit.*, p. 24), the portrait of Davidson was painted in 1662. "D. Schultz" was Daniel Schull, Schult or Schultz (1620–86), a native of Dantzig who studied in Paris and Breslau and became a portrait painter. Pierre Lombart (1620–81) was a Parisian engraver, who executed many fine engravings of portraits.

obstacles and working under great handicaps in a much troubled age. He was steadfast in his loyalties. Throughout his long life he remained loyal to the land of his birth; he was also loyal to the countries of his adoption, loyal to his colleagues, loyal to what he considered the best interests of his science, and loyal to his religion.

It is significant of still one more loyalty that *Plicomastix*, the last book he published, was printed at Aberdeen. This apostle of the art of fire kept a very warm corner in his heart for his *alma mater*. In 1634, John Forbes of Corse, Rector of King's College, Aberdeen, who was anxious to revive and extend the ancient privileges of the College, wrote to Davidson asking for information about the constitution and regulations of the University of Paris. Davidson at once went to see the Rector of that University and forwarded the resulting information, remarking in his reply that "if you neid any moir they have promised to lat anie man be me imployit copie their registers, the quhilks ar bigger than any gryt byble . . . yow shal be assurit that nather lake of freinds, nor paine nor expenssis sall gainstand your most iust desire". The minutes of the University testify that a letter of thanks was sent to "the said Doctour W. Davissoune, thanking him for his love and paines in the erand aforesaid; and giving him commissioun and powar . . . for to caus subscryve ane autentik copie . . .and to bestow theropoun tua hundredth franks or thereby, if it may not be had cheaper"[53]

Davidson's bonnet was not devoid of bees. He was obsessed by such notions as geometrical mysticism, the unique virtues of antimonial medicines, and the importance to France of his imagined Law of Salt. In these matters, however, he must be regarded as a child of an age that revelled in ideas based upon allegory, symbolism, mysticism, and bizarre doctrines like those of sympathy and signatures. The 17th century was an age of unbounded credulity and superstition.

"Nobilis Scotus"

The French, who should know the Scots well—seeing that Davidson alluded in 1651 to an auld alliance of nine centuries' standing[54]—have an ancient proverb, "Fier comme un Ecossois!" The proverb never fails, wrote Sir Walter Scott in *Quentin Durward*, adding, "A true Scot! Plenty of blood, plenty of pride, and right great scarcity of ducats!"

"Proud as a Scotsman!" The proverb applied in full force to Davidson, who took an intense pride in his country and particularly in the blue blood of

[53] Small, *op. cit.*, **10**, 269.

[54] *Les Elemens*, p. 400.

Scotland that ran in his own veins; moreover, in those days it was essential for an aspirant to any appointment of eminence in a foreign land to demonstrate his noble descent. In 1629 Davidson went to great pains to secure a patent of nobility from Charles I, after which he styled himself "Nobilis Scotus". Near the end of his life, in 1669, he obtained from Louis XIV a ratification of this certificate, granting to himself, his son Charles, and later descendants all the rights and privileges enjoyed by Frenchmen of noble birth[55]. Moreover, in his commentary on Severinus, Davidson pointed out that "although it may be considered that I have made choice of an unsuitable station in life, inasmuch as I, who am born of one of the most noble families of Scotland, have embraced the medical profession, yet it must be borne in mind . . . that amongst the Scots, professors of medicine were invested with such honour by the kings of Scotland that they enjoyed a title equal to that of earls, and it is certain that they enjoy such title to this day". Davidson's descendants remained in France and became completely gallicized; but in view of the importance he attached to the Salic Law it is well that he could not foresee that the family was destined to descend in a later generation through the female line[56].

At the foot of Davidson's portrait appears his coat of arms. The same design was appended to the engraved "Emblema Totius Operis" (Fig. 5) of his *Philosophia Pyrotechnica*, together with the motto: "Fortunam humuli memento figere saxo", "Remember to attach fortune to a lowly stone". . . . At first glance the motto appears inapposite, particularly as Davidson showed no tendency to pin his own fortune to lowly stones in the dedications of his books, in days when a career was so dependent upon patronage. It must be recalled, however, that Davidson was deeply tinged with the symbolism and mysticism of alchemical thought and reasoning. The "lowly stone" is the Philosopher's Stone, upon which Psyche and Proteus each rest a foot in the emblem[57]. In *Gloria Mundi* (1526) a statement typical of alchemical ambivalence tells that the Philosopher's Stone "is familiar to all . . . yet it is despised by all. Rich and poor handle it every day. It is cast into the street by servant maids. Children play with it. . . . It is the most beautiful and the most precious thing upon earth . . . nevertheless, it is esteemed the vilest and meanest". To pin his fortune to a lowly Stone capable of acting as an unending source of health and wealth was wholly in keeping with the ambitions and aspirations of William Davidson, "Nobilis Scotus".

[55] Small, *op. cit.*, **10**, 278.

[56] Hamy, *op. cit.*, p. 23, footnote.

[57] The Philosopher's Stone was often represented by a brick-like parallelepiped: see, e.g. *Prelude to Chemistry*, plate 21.

Envoi

Although imbued with the theoretical ideas of his alchemical predecessors and given to associating the doctrines of chemistry with religious and metaphysical conceptions, in his practical outlook William Davidson has claims to be called a chemist rather than an alchemist. In this respect he has affinities with Beguin and Glauber, as one looking forward to chemistry rather than backward to alchemy after the general fashion of his age. An alchemist in theory, he was a chemist in practice[58].

It was meet and right that in the tercentenary year of his crowning appointment the ancient University of Aberdeen should have resolved to salute the memory of a loyal alumnus who played so worthy a part in the advancement of 17th-century science, during the period of transition from alchemy to chemistry. Of him, as of his fellow alumnus, Duncan Liddel, it may be said[59] that "in a foreign country, without fortune or the connection of family, he arrived at the highest honours of his profession, and was distinguished as one of the first physicians and philosophers of his time".

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[58] *Humour and Humanism in Chemistry*, p. 91.

[59] J. Stuart, *A Sketch of the Life of Dr. Duncan Liddel, of Aberdeen*, Aberdeen, 1790.

NOTES ON THE IMPORTANCE OF ALCHEMY TO MODERN SCIENCE IN THE WRITINGS OF FRANCIS BACON AND ROBERT BOYLE

By Muriel West*

The writings of Francis Bacon and Robert Boyle clearly indicate that whereas Bacon, perhaps unwittingly, frequently concealed the alchemical source of his knowledge, Boyle adopted a deliberate secretiveness in this respect; hence his name has sometimes been associated with magic and mysticism[1]. But as an exponent of "the experimental philosophy, of which Francis Bacon had merely talked in Utopian fashion", Boyle endeavoured to penetrate the mystifying veils of alchemical metaphor and, unlike Bacon, who imparted only general information extracted from the alchemical literature, he was able to elucidate some of the practical secrets of the alchemists (or "chymists", as Boyle prefers to call them). Bacon may have had some direct influence on Boyle, but presumably most of the important current of alchemical knowledge that Boyle transmitted to science came directly from the alchemists, or at least was suggested by them.

For instance, when Boyle reports on his experiments concerning respiration, he pays Bacon rather dubious respect when he says that as a true disciple of the "great Verulam" he sets forth his "doubts", a tribute that seems even more dubious when one observes that he presently says he prefers, with the "acute St. *Austin*", to confess cautious ignorance rather than profess false knowledge[2]. But Boyle's daring, his inspiration in the same enterprise, came from Paracelsus, as he freely admits:

> . . . there is some use of the Air, which we do not yet so well understand, that makes it so continually needful to the Life of Animals. *Paracelsus* indeed tells us, *That as the Stomack concocts Meat, and makes part of it useful to the Body, rejecting the other part, so the Lungs consume part of the Air, and proscribes the rest.* So that according to our Hermetick Philosopher

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[1] Louis Trenchard More, *The Life and Works of the Honourable Robert Boyle*, London, 1944, pp. 189, 218; Lynn Thorndike, *History of Magic and Experimental Science*, New York, 1958, VIII, pp. 180–181, see also p. 171.

[2] Quoted by Douglas McKie, "Some Early Work on Combustion, Respiration and Calcination", *Ambix*, I, No. 3 (Mar., 1938), pp. 153, 155, from Boyle's Experiment 41 in *New Experiments Physico-Mechanicall, Touching The Spring of the Air* . . . Oxford, 1660, pp. 336, 383.

> (as his followers would have him stil'd) it seems we may suppose, that there is in the Air a little vital Quintessence (if I may so call it) which serves to the refreshment and restauration of our vital Spirits, for which use the grosser and incomparably greater part of the Air being unserviceable, it need not seem strange that an Animal stands in need of almost incessantly drawing in fresh Air[3].

It seems that Boyle gave Bacon the courtesy due the name of Verulam but it is not improbable that he spoke of him among others when he says that he "must complain" of those "eminent writers, both physitians and philosophers", who have:

> suffered themselves . . . to publish and build upon chymical experiments, which questionless, they have never tried; for if they had, they would, as well as I, have found them not to be true. And indeed it were to be wished that . . . they . . . would rather for each experiment they alleged, name the author or authors upon whose credit they relate it; for, by this means . . . they would leave the reader to judge of what is fit for him to believe, . . . whilst they employ not their own great names to countenance doubtful relations[4].

When one compares Bacon's knowledge and understanding of alchemy with Boyle's, it becomes plain that—on this count at least—Bacon could not have impressed him very much. Bacon's remarks on alchemy show considerable confusion of mind—a confusion not easy to account for. He contradicts himself at every turn. One might say that he was afflicted with a strange compulsion to use the antithetical rhetorical devices so noticeable in the Proverbs of Solomon: a positive statement followed by a "but" with a not-always-pertinent contrasting negative; or that he could not avoid being swayed this way and that by the Idols of the Theatre—to use his own expression. He censures the alchemists in the manner of Erastus—who said the Light of Nature of Paracelsus was rather the light of the devil, of his cohorts, and of hell[5]; he censures them again in the milder manner of Cornelius Agrippa —as deluders either of themselves or of others, who yet had made some worthwhile discoveries[6]; and with smug piety he takes them to task for "an admixture of theology", which, he says, "does the most harm"[7]. He blames them for supposing they could transmute metals and prolong life, and then says *but* these wonders *are* possible—if one follows Bacon's suggestions instead

[3] Quoted by McKie, *loc. cit.*, p. 154, from Exp. 41, p. 362.

[4] *Sceptical Chymist*, Everyman ed., London, 1911, pp. 3–4.

[5] Erastus quoted by Walter Pagel, *Paracelsus*, New York, 1958, p. 315; *cf.* Bacon in *Works*, ed. Spedding, Ellis, and Heath, London, 1868–92, IV, pp. 84, 367; henceforth designated as *Works*.

[6] *Works*, IV, p. 84.

[7] *Ibid.*, IV, pp. 65–66.

of the foolish methods of the alchemists. Most curiously, Bacon's wise suggestions are merely a rehash of often-repeated alchemical maxims: to make gold, one must discover the proper substance to begin with and use only a moderate heat with the temperature kept steady for a rather long period of time; to prolong life, one must discover a substance that will do the same thing for the living body that known preservatives do for a dead body; Bacon recommends "nitre" (saltpetre) because it cools and restrains the spirits and keeps a man from wearing himself out[8].

The other two alchemical motives (making glass malleable and changing ordinary stones into gems) he seems (or pretends) not to know are alchemical, but he does make suggestions; and he tells us in detail how to congeal ordinary water into crystal[9]. Also he presents many an alchemical concept or catchphrase as his own: anything that has the properties of gold is gold[10]; he suggests that distillation in close (never tried before, he says) should be investigated[11]; he addresses his readers as "sons of knowledge"[12]; he likes to talk of those so blind that they wander all around Nature's labyrinths without ever discovering her secret chamber; he echoes the incessantly-repeated Nature-loves-Nature phrase attributed to Democritus in the first place[13]. Of most importance, perhaps, Bacon never tires of praising the Light of Nature and of insisting on experiment, experiment, and more experiment—themes worn almost threadbare by the alchemists from the times of Democritus[14] and the Alexandrian Archelaos[15], through Arnold of Villanova[16] and Paracelsus (called

[8] *Ibid.*, II, p. 459; IV, p. 392; V, p. 274.

[9] *Ibid.*, III, p. 803; II, p. 462. For a comprehensive explanation of the four alchemical motives see *Aurora Consurgens*, in *Auriferae Artis*, Basileae, 1572, I, pp. 261–265.

[10] *Ibid.*, II, p. 450; *cf. The New Pearl of Great Price*, ed. A. E. Waite, London, 1894, p. 91.

[11] *Works*, II, p. 383; IV, p. 420.

[12] *Ibid.*, IV, p. 42.

[13] *Works*, IV, pp. 81, 393. Democritus quoted by J. M. Stillman, *The Story of Alchemy and Early Chemistry*, [1924], New York, 1960, p. 158.

[14] Stillman, *op. cit.*, p. 159.

[15] *Poem of the Philosopher Archelaos upon the Sacred Art*, trans. C. A. Browne, *Ambix*, II, Nos. 3 & 4 (Dec., 1946), p. 131.

[16] *The Glory of the World* in *The Hermetic Museum*, ed. A. E. Waite, London, 1893, I, 233, makes clear the remarkable persistence of the nature theme in alchemy: "Hence all that would receive this Art must know the properties of the most noble substance thereof, and follow the guidance of Nature. But many enquirers conduct their operations at haphazard, they grope in the dark and do not know whether their Art be an imitation of Nature or not. Yet they undertake to correct and intensify the operation of Nature. Of such persons Arnold says that they approach our Art as the ass goes up to the crib, not knowing for what it opens its mouth. For they do not know what they would do, nor are they aware that they must listen to the teaching of Nature".

a fanatic of experiment)[17], straight up to our own time in the writings of Fulcanelli, Alleau, and other twentieth-century adepts[18].

Bacon may have realized that he could be accused of distorting the truth when he passes off as "new" his belief in taking Nature as his Book, and Experiment as his Method. He tries to justify himself by pointing out that the alchemists ignore the "middle axioms" while they leap back and forth between universals and particulars[19]. Certainly the world at large has accepted Bacon's ideas as new, still giving him credit (as recently as 1960) for the "immense practical vision" that made modern science possible[20].

Although Robert Boyle is generally referred to as a "Baconian, convinced that experiment was the only key to natural philosophy"[21], there is no reason for supposing that he thought that Francis Bacon had actually invented the

[17] *Paracelsus Selected Writings*, ed. Jolande Jacobi, trans. Norbert Guterman, New York, 1951, pp. 46, 55; see also *Four Treatises of Theophrastus von Hohenheim Called Paracelsus*, ed. Henry E. Sigerist, Baltimore, 1941, p. 211: "This is the effect of the tincture on stones and metals. Those who want to make it should not just believe that they know it, but should really know it, for its preparation is the most dangerous work in alchemy. It must be thoroughly tried and frequently used, and must be known not only by hearsay but by one's own knowledge and experiment".

Emphasis on nature in Bacon and Paracelsus sound like excerpts from the same work; compare Bacon's Aphorism I, *Works*, IV, p. 47:—"Man, being the servant and interpreter of Nature, can do and understand so much and so much only as he has observed in fact or in thought of the course of nature: beyond this he neither knows anything nor can do anything"—with *Paracelsus* (ed. Jacobi), *op. cit.*, pp. 178, 179, 183: "Everything that man does and has to do, he should do by the light of nature. For the light of nature is nothing other than reason itself. Only he is the enemy of nature who fancies himself wiser than nature, although she is the greatest school for all of us. . . . We are born to be awake, not to be asleep! . . . Therefore, man, learn and learn, question and question, and do not be ashamed of it; for only thus can you earn a name that will resound in all countries and never be forgotten. . . . It is God's will that nothing remain unknown to man as he walks in the light of nature; for all things belonging to nature exist for the sake of man. And since they have been created for his sake, and since it is he who needs them, he must explore everything that lies in nature".

[18] Fulcanelli, *Le Mystère des Cathédrales*, Paris, 1926, pp. 141–142; René Alleau, *Aspects de l'Alchimie Traditionelle*, Paris, 1953, pp. 27–28; Claude d'Ygé, *Nouvelle Assemblée des Philosophes Chymiques*, Paris, 1954, pp. 41–42: "Il peut en marge du Grand Œuvre faire de fréquents essais pour éclairer sa théorie, et pour apprendre de la Nature ce que jamais aucun texte ne pourra lui faire connaître vraiment".

[19] See *Works*, IV, p. 41, for Bacon's claim that what he offers is "new"; he tempers his boast thus: "I appear merely as a guide to point out the road; an office of small authority, and depending more upon a kind of luck than upon any ability or excellency". See also IV, pp. 50, 64, 74, 75, 81, 367.

[20] Neal Gilbert, *Renaissance Concepts of Method*, New York, 1960, p. 226.

[21] Marie Boas, *Robert Boyle and Seventeenth-Century Chemistry*, Cambridge, England, 1958, pp. 27, 34; Lynn Thorndike, *Magic and Experimental Science*, VIII, pp. 180, 198.

experimental method, nor for doubting Boyle's own word when he says, "I have purposely refrained . . . from seriously and orderly reading over those excellent (though disagreeing) books [Gassendi's *Syntagma*, Descartes' *Principles of Philosophy* and Bacon's *Novum Organum*] . . . that I might not be prepossessed with any theory or principles"[22]. In the *Sceptical Chymist* Boyle shows that he highly valued for their experiments the "chymists", the "spagyrists", the "hermetick philosophers", the "artists", as he calls those older writers who are more often called "alchemists"[23]. It seems highly significant that never throughout the whole book does he mention Francis Bacon's connection with experiment—or even his name—so much as once. Sometimes elsewhere, as already pointed out, he pays him lip-service as the "great Verulam" and he includes him in lists of notables, as when he says he found Aristotle's principles opposed, "not only by the Chymists in generall & great store of Moderne Physitians but by acute & fam'd Philosophers & the sect of the new Copernicans, Telesius, Campanella (& his ingenious Epitomist Comenius), Bacon, Gassendus, Descartes & his sect, to name no more"[24].

But Boyle may have been challenged by Bacon's rather pathetic (even if tacit) admission that the "fanciful and tumid and half poetic" style of the enigmatical writers was beyond his comprehension. Bacon says they mislead by "flattery", for there is in man "an ambition of the understanding, . . . especially in high and lofty spirits"[25]. Boyle's "ambition of the understanding" was teased into activity: he did pierce the veil of obscurity that, according to Bacon, was intended "to exclude the vulgar . . . from the secrets of knowledge and to admit those only who had either received the interpretation of the enigmas through the hands of teachers or have wits of such sharpness and discernment as could pierce the veil"[26].

Boyle accepted the challenge in two ways: he exercised the sharpness of his wits by diligently reading the works of the "chymists" and he sought out "teachers" to give him the "interpretation of the enigmas", as an examination of the *Sceptical Chymist* makes manifest. He praises van Helmont, and defends him, saying: ". . . so faithful a writer, even in divers of his improbable experiments (I alwaies except that extravagant treatise *De Magnetica Vulnerum Curatione*, which some of his friends affirm to have been

[22] Quoted from "*Proemial Essay*" to *Physiological Essays* in Boyle's *Works*, London, 1744, I, p. 194; also cited in Boas, *op. cit.*, p. 27, but with the closing word "principles" misquoted "particulars".

[23] *Sceptical Chymist*, pp. 116, 117, 166, 184, 187, and *passim*.

[24] Quoted from the Royal Society collection of Boyle's manuscripts catalogued as Boyle Papers, vol. 38, by Boas, *loc. cit.*, p. 27.

[25] *Works*, IV, p. 66.

[26] *Ibid.*, IV, p. 450.

first published by his enemies)"[27]. He often mentions Paracelsus and his school and quotes him at length in Latin[28], thus showing a familiarity with his work that contrasts sharply with Bacon's patronizing confusion—a confusion made painfully evident when he says: "The admirable effects of this distillation in close (for so we call it), which is like the wombs and matrices of living creatures, where nothing expireth nor separateth; . . . not that we aim at the making of Paracelsus' pygmies or any such prodigious follies"[29]. Bacon apparently was unaware that "pygmies" are the "little people who guard treasures in the earth", and not the "homunculi" that are created by the "artist"[30].

Boyle also respected Raymond Lull, classing him with Paracelsus and other "eminent writers" who "yet do so abuse the termes they employ, that as they will now and then give divers things, one name; so they will oftentimes give one thing many names; . . . nay even in technical words or termes of art, they refrain not from this confounding liberty; but will, as I have observed, call the same substance, sometimes the sulphur, and sometimes the mercury of a body"[31]. But Boyle finds it worthwhile to say, "Raimund Lully himself teach[es] that merely by the fire quicksilver may in convenient vessels be reduced . . . into a thin liquor like water, and minglable with it", and even intimates with a second reference that he has seen this "water" and tasted it himself[32]—a subtle way of indicating he has pierced the veil of deliberate Lullian ambiguity that Bacon, unable to penetrate, heaped with ridicule:

> . . . some persons more ostentatious than learned have laboured about a kind of method not worthy to be called a legitimate method, being rather a method of imposture, which nevertheless would no doubt be very acceptable to certain meddling wits. The object of it is to sprinkle little drops of science about, in such a manner that any sciolist may make some show and ostentation of learning. Such was the Art of Lullius, . . . being nothing but a mass and heap of the terms of all arts, to the end that they who are ready with the terms may be thought to understand the arts themselves[33].

[27] *Sceptical Chymist*, p. 51; for other references to van Helmont see pp. 36, 42, 49, 67, 68–70, 73, 75, 76, 79, 104, 118, 125–128, 138, 140, 144, 162, 181, 184, 186, 189, 199, 202–204, 207–208, 211, 213–214, 220.

[28] *Ibid.*, pp. 59, 151; see also pp. 18, 22, 23, 49, 105, 107, 113, 114, 130, 146, 152, 162, 176, 184, 186, 199.

[29] *Works*, II, p. 383.

[30] For the "pygmies" see "A Book on Nymphs, Sylphs, Pygmies, [etc.]", *Four Treatises*, *op. cit.*, pp. 223–253; for the "homunculus" see Pagel, *op. cit.*, pp. 87, 117, 215–216, 335.

[31] *Sceptical Chymist*, p. 113.

[32] *Ibid.*, pp. 129, 208.

[33] *Works*, IV, p. 454.

Besides studying the works of van Helmont, Paracelsus, Lull, and dozens of others among the enigmatical "chymists" and piercing the veil of deliberate obscurity with the sharpness of his wit, Boyle missed no opportunity to converse with "adepti" by whom he would both "willingly and thankfully be instructed; especially concerning the nature and generation of metals"[34]. (Evidently he did not find Bacon's suggested experiments for transmuting base metals into gold and silver very helpful.) And throughout the *Sceptical Chymist*, although Boyle steadily blames the "chymists" for their "aenigmatical . . . cloudy expressions", their "intolerable ambiguity", the licence they take to "abuse words"[35], he also steadily drops hints (in the course of a prolonged four-cornered conversation) on how this "equivocal way of writing" is to be understood. Certainly he makes it clear that none of the "mystical termes and ambiguous phrases" that add the trouble of "guessing at the sence" of what is "equivocally" expressed are anything but devices for confusing the uninitiated[36]. He shows no tendency to feel as Bacon did that the magic and religion in the "chymists'" writings contributed to the "corruption of philosophy", or to say with Bacon:

> Yet in this vanity some of the moderns have with extreme levity indulged so far as to attempt to found a system of natural philosophy on the first chapter of Genesis, on the book of Job, and other parts of the sacred writings; seeking for the dead among the living [*sic*]: which also makes the inhibition and repression of it the more important, because from this unwholesome mixture of things human and divine there arises not only a fantastic philosophy but also an heretical religion. Very meet it is therefore that we be sober-minded, and give to faith that only which is faith's[37].

Indeed, Boyle probably learned (as Bacon could have done if he had read enough and been alert enough) from the works of the "chymists" themselves that alchemy is a "physical science", as Petrus Bonus of Ferrara says, "for it deals with the real being joined to motion and matter, and not with metaphysics, which are divine"[38]. Likewise, both of them could have learned from Croll, Severinus, Dorn, and Gohory, who, in defending Paracelsus, Trithemius, and others from the charges of such deriders as Erastus, said that the "spirits" represent extracts and essences, properties and methods of

[34] *Sceptical Chymist*, p. 8.

[35] *Ibid.*, pp. 146–147, 113, 143.

[36] *Ibid.*, p. 115, and *passim*.

[37] *Works*, IV, p. 66; see also IV, p. 88, and *passim*.

[38] *New Pearl, op. cit.*, p. 185.

preparation, or mineral, vegetable, and animal things—in short that the basic subject-matter of alchemy must be understood as chemistry[39].

Probably Boyle's greatest advantage over Bacon in understanding alchemy lay in his personal acquaintance with such famous alchemists as, for example, Philalethes[40]. He is secretive about his "chymist" friends, not using their names but speaking thus: "I . . . once met an old and famous artist, who has long been (and still is) chymist to a great monarch"[41]; or thus: ". . . an eminent person, whose name, his travells and learned writings have made famous, lately assured me [here one may observe that Boyle did everything he could to obtain secrets from his honoured friends] that he had more than once seen the mercury of lead (which whatever authors promise, you will find it very difficult to make . . .) fixt into perfect gold. And being by me demanded whether or no any other mercury would not as well have been changed by the same operations, he assured me of the negative"[42].

By examining some of Boyle's interrelated particulars concerning "mercury" and what might be done with it and deducing therefrom a few Baconian "middle axioms", it is possible to show how efficiently Boyle succeeds (in one example, at least) in accomplishing his purpose of assisting "less skilful readers" to understand how the alchemists arrive at their incredible universals. Before mentioning the "mercury of lead" that is fixed into "perfect gold", Boyle has explained that "mercury" in alchemical writings is thoroughly ambiguous: it may be a liquid (or even a gas) of almost any kind[43], but, particularly, "mercuries" are metallic, such as the "quicksilver of tin or pewter (*argentum vivum ex stanno prolicitum*) [that] may [like the mercury of lead] by an efficient cause . . . be turned into pure gold"[44]. Boyle apparently pestered his famous friends into divulging secrets that they made him promise not to reveal in

[39] Gabriel Naudé, *Apologie pour les grands hommes soupçonnez de magie* [1625] (Amsterdam, 1712), pp. 280, 364–365. See also D. P. Walker, *Spiritual and Demonic Magic*, London, 1958, p. 101: "Gohory . . . freely admits there is much he does not understand in them [Paracelsus' writings], even that he cannot be sure whether in some cases they are about alchemy or the soul or astrology or medicine or something else" (from Leo Suavius, *Theophrasti Paracelsi . . . Compendium*, Basiliae, 1568, p. 309).

[40] Louis Figuier, *L'Alchimie et les Alchimistes*, Paris, 1860, p. 313, n. 1.

[41] *Sceptical Chymist*, p. 101.

[42] *Ibid.*, p. 150.

[43] *Ibid.*, pp. 99–104, 134–135, 146–150; see also pp. 155, 159, 169, 187, 196. Boyle also explains that "sulphur" (usually the "sulphur of gold") is just as ambiguous as mercury —pp. 98, 101, 117, 195–196. On page 176 he hints at one of the fundamental alchemical meanings: "Sennertus . . . dissents from both; and referrs colours rather unto sulphur", a passing remark that throws light on the half-page of Latin quoted from Paracelsus on p. 151.

[44] *Ibid.*, p. 150.

plain words; but it is also fairly obvious that with his intense "ambition of the understanding", he pieced together scraps of equivocal information found in his reading. Paracelsus, for instance, buries (or, one might say, "hermetically seals") in a tract entitled "Diseases That Deprive Man of Health and Reason", the unsupported passing comment: ". . . another of nature's powers is that of making living mercury out of lead by borax water"[45], a remark that would lead anyone familiar with the rudiments of glass manufacture to form at least a tentative hypothesis: "mercury of lead" is glass, and if it is "living" (that is, "quick" as in "quicksilver" or in the "quick and the dead") it is molten. It is noteworthy to recall that early in Part I of the *Sceptical Chymist* (p. 32 of the cited edition) Boyle quite casually says: ". . . some there are who affirm, that by proper additaments they can reduce quicksilver into . . . glass". Of course, the meaning becomes clearer when Boyle twice points out that lead, one of the most opaque and malleable substances in the world, can be changed to a fine transparent glass "merely by the manner and the method of exposing it to the fire". Further, it can be changed back, made opaque and malleable again[46]. Not all glass contains lead, but the most beautiful heavy cut-glass is sure to contain a high percentage of lead.

Boyle thus, in passing, accounts for one of the most preposterous claims of the alchemists—that they can make glass malleable. Also, he has given important clues to the kind of "mercury" his eminent friend had seen "fixt into perfect gold". That the word "gold" is also an ambiguous term with the alchemists may be taken for granted. They insist that their gold is not the gold of the vulgar, but a gold much better and finer; according to Paracelsus it is gold "exalted to such a degree of transparency that no metal can corporeally ascend higher"[47]. Boyle seems to have understood quite well what Paracelsus meant, but he is so cautious in telling what he knows that one finds great significance in his prefatory comment that in revising the *Sceptical Chymist* for publication (he had written it in the first place merely to "gratify an ingenious gentleman"), he thought it best to "retrench some things that seemed not so fit to be shewn to every reader"[48], and in his saying somewhere else that he kept some experiments concealed so that he would "always [be] provided with some Rarity to barter with those Secretists that will not part

[45] *Four Treatises of Theophrastus von Hohenheim Called Paracelsus*, ed. Henry E. Sigerist, Baltimore, 1941, p. 189.

[46] *Sceptical Chymist*, pp. 183, 217.

[47] *The Hermetic and Alchemical Writings of Paracelsus*, ed. A. E. Waite, London, 1894, I, p. 153; *cf.* Locatelli, cited by Thorndike, VII, p. 196.

[48] *Sceptical Chymist*, p. 1.

with one Secret but in exchange for another"[49]. One gradually wakes up to the ironical truth that Boyle himself employs—and in the very same book—the enigmatical techniques that he argues so forcefully against.

In short, he reveals (for one thing) that the gold exalted to the highest degree of transparency is more than likely real gold (real in a sense) in a state of fine subdivision that gives the marvellous colour to gold-ruby glass. Boyle's scattered information is often elusive, but some of it is plain enough: for instance, the identification of "metal" as the name the workmen in the glasshouse give the "mass of colliquated ingredients which, by blowing they fashion into vessels of divers shapes"[50]. Lead glass may thus be understood as the "base metal" that the alchemists transmuted into "gold". Boyle becomes more subtle when he observes that sometimes this "metal" is of a "very differing colour", a colour accounted for by the workmen as due to ashes of one kind or another[51]. Also, when he switches the talk from the "not real" colours of "the triangular glass" (prism) to a couple of examples of "real and permanent colours drawn from metalline bodies", the passage requires careful reading to avoid jumping to the conclusion that he is talking about cinnabar. The "quicksilver" is deprived of its "silver-like colour" and is "turned into a red body; and from this red body . . . may be obtained a mercury bright and specular as it was before"[52]. The glassy context, however, and the use of "a" mercury and of the word "specular" suggest that Boyle is telling his more curious readers that "*a* mercury" associated with the colour red is an important glassmaking secret. Some pages further on he says that with a substance "which our friend [presumably Boyle himself] has made, and intends shortly to communicate to the ingenious", he has "really destroyed even refined gold, and brought it into a metalline body of another colour and nature"[53]. One might ask, what does he mean by "destroyed"? At the least he seems to imply that he has puzzled out what the alchemists mean when they say, "It is easier to make gold than to destroy it", an expression Boyle himself has earlier called "almost proverbial", saying that "our famous countryman Roger Bacon has particularly adopted it"[54]. Further than that,

[49] Thorndike, VIII, pp. 180–181, quotes from Sir Clifford Allbutt, *Greek Medicine in Rome*, 1921, pp. 515–516.

[50] *Sceptical Chymist*, p. 137; see also p. 40.

[51] *Ibid.*, p. 137.

[52] *Ibid.*, pp. 176–177.

[53] *Ibid.*, pp. 215–216.

[54] *Ibid.*, p. 100.

he probably means he has changed the gold into one of its several possible unstable compounds that he has already described:

> And the same gold will also by common *aqua regis*, and (I speak it knowingly) by divers other menstruums, be reduced into a seeming liquor, insomuch that the corpuscles of gold will, with those of the menstruum, pass through cap-paper, and with them also coagulate into a crystalline salt. And I have further tried, that with a small quantity of a certain saline substance I prepared, I can easily enough sublime gold into the form of red crystals of a considerable length; and many other wayes may gold be disguised, and help to constitute bodies of very differing natures both from it and from one another, and nevertheless be afterward reduced to the self-same numerical, yellow, fixt, ponderous, and malleable gold it was before its commixture[55].

After an interval of some fifty pages, Boyle links up the gold-compound and lead-glass ideas. It is, perhaps, doubtful whether Bacon would have understood what Boyle really meant to convey, but anyone with a practical knowledge of glass-colouring techniques would appreciate that Boyle is referring to gold-ruby glass (of high lead content) when he says:

> . . . though when common gold and lead are mingled together, the lead may be severed almost unaltered from the gold; yet if instead of gold a tantillum of the red elixir be mingled with the saturn, their union will be so indissoluble in the perfect gold that will be produced by it, that there is no known, nor perhaps no possible way of separating the diffused elixir from the fixed lead, but they both constitute a most permanent body, wherein the saturn seems to have quite lost its properties that made it be called lead, and to have been rather transmuted by the elixir, than barely associated to it[56].

By scattering his information in the established alchemical manner prescribed centuries before by Geber[57], Boyle has concealed, under the guise of a tediously long harangue on the ridiculousness of the *tria prima*, the four principles of the peripatetics, and the chymists' "intolerable ambiguity", a wealth of knowledge about glass, with particular emphasis on the gold-ruby. He has shown what it means to transmute the base metal, lead, into gold

[55] *Ibid.*, p. 31.

[56] *Ibid.*, p. 90.

[57] *The Works of Geber, Englished by Richard Russell*, 1678, ed. E. J. Holmyard, London, 1928, pp. 214, 222: "We will set down all *Waters* dissolutive of *Spirits* and *Bodies*, in the *End* of this *Book*; and every one of these according to his own kind; and wonder not, that We have dispersed the special Things pertinent to this *Praxis*, in diverse *Volumes*, seeing we endeavour to hide the *Art* from evil *Men*. . . . Keep this *Stone*, and considerably ruminate of what we have taught in our *Summe of Perfection*, and you will attain to higher *Things*, for our purpose was not in one only *Volume* to demonstrate all *Things*; but that *Book* should declare *Book*, and expound the same".

exalted to such a degree of transparency that no metal can corporeally ascend higher. It is curiously ironic that Bacon, who believed in transmutation as it is ordinarily understood, is never accused of being an "alchemist", and that Boyle, who understood the scientific truth underlying the mystifying language, is still apologized for even by his most sympathetic biographers for his belief that transmutation was a perfectly possible chemical operation[58].

One may wonder if Boyle's emphasis in the *Sceptical Chymist* on glass and gold compounds, with hints at the gold-ruby, may be related to some of his mystifying papers, such as *An Experimental Discourse of Quicksilver growing hot with Gold* that provoked Newton into saying he questioned "not, but that the great wisdom of the noble author" would "sway him to high silence"[59], related also to Newton's correspondence with Locke after Boyle's death concerning the "red earth" and recipes for its use[60]. And perhaps it may be of relevant significance to note that in the year following the first appearance of Boyle's *Sceptical Chymist*, Christopher Merret had dedicated his published translation of Antonio Neri's *L'Arte Vetraria* "to the Honourable, and true promoter of all solid learning, Robert Boyle, Esq.",—wherein it is said:

> . . . some will, . . . that the invention of Glass was found out by the Alchymists; for they, desiring to imitate Jewels, found out Glass; a thing not far from the truth; for as I shew, . . . the manner of imitating all Jewels, in which way is seen the vitrification of stones which of themselves will never be melted or vitrified[61].

It is not possible, within the scope of this paper, to evaluate how much Boyle's *Sceptical Chymist* may have assisted Cassius and Kunckel in their investigations that finally made the gold-ruby process more or less common knowledge; nor to determine how much Stahl's statement, that the Philosophers' Stone

[58] Marie Boas, *Robert Boyle and Seventeenth-Century Chemistry*, Cambridge, England, 1958, p. 102.

[59] See D. Geoghegan, "Some Indications of Newton's Attitude towards Alchemy," *Ambix*, VI, No. 2 (Dec., 1957), pp. 102–103.

[60] *Ibid.*, pp. 103–104.

[61] *The Art of Glass*, London, 1662, p. 3. Neri also gives what is called the first gold-ruby recipe written in plain language (Merret trans., p. 192): "A transparent Red. Calcine Gold with *Aqua-regis*, many times, pouring the water upon it five or six times, then put this powder of Gold in earthen pans to calcine in the furnace until it becomes a red powder, which will be in many days, then this powder added in sufficient quantity, and by little and little, to fine Crystall glass which hath been often cast into water, will make the transparent red of the Rubie as by experience is found".

For an excellent history of gold-ruby glass, see W. Ganzenmüller, "Beiträge zur Geschichte des Goldrubinglases", *Beiträge zur Geschichte der Technologie und der Alchemie*, Weinheim, 1956, pp. 85–128. For the most comprehensive modern work, see Woldemar A. Weyl's well-indexed *Coloured Glasses*, London, 1959.

existed in the ruby-glass windows of old churches[62], may have been suggested by Boyle whom he greatly admired. Certainly from time to time it has been suspected—even by so thorough and cautious a scholar as the late F. Sherwood Taylor, that the purple of Cassius was known to the ancients[63]. But to conclude this present article, it may be inferred that Francis Bacon read the plain truths of alchemy: Experiment is the Method and Nature is the Book; and that Robert Boyle investigated some of the practical secrets of the alchemists, tested them, and passed them on as best he could to posterity.

[62] Louis Figuier, *L'Alchimie et les Alchimistes*, Paris, 1860, p. 66.

[63] "Alchemical Works of Stephanos of Alexandria", *Ambix*, II, No. 1 (June, 1938), 48, n. 111: "It is hard to resist the suggestion that this is the earliest reference to purple of Cassius".

REVIEWS

A Bibliography of the Hon. Robert Boyle. By JOHN F. FULTON. Second Edition. Pp. xxvi + 218. Clarendon Press: Oxford University Press, 1961. Price 50s.

IN this new edition of his well-known *Bibliography*, Professor Fulton has incorporated all the material which has come to light during the thirty years that have elapsed since his completion (as he tells us) of the first edition in August, 1930; the original text, first published in 1932, has also been included together with the two *Addenda* (1933 and 1947), and the introductory notes to the major works have been extensively revised.

To cite an example in this connexion, we may refer to the misstatement (on pages 20–21 of Professor Fulton's original text) that although Boyle's first air pump was designed by Hooke "there is no acknowledgment to him in the first edition of Boyle's 'Spring and Weight of the Air' . . . and . . . Boyle failed to make specific mention of him in 1660". Apparently it had been overlooked that, on pages 6–7 of the 1660 edition, Boyle did, in fact, make due acknowledgment to Hooke: ". . . I put both Mr. G[reatorex] and *R. Hook* (who hath also the Honor to be known to your Lordship, and was with me when I had these things under consideration) to contrive some Air Pump. . . . And after an unsuccessful tryall or two of ways propos'd by others, the last nam'd Person fitted me with a Pump, anon to be describ'd".

In the present revision the error in question has been deleted, but Professor Fulton does not interpret Boyle's acknowledgment as more than a "passing reference"—although in his essay on Robert Boyle (cf. *The Royal Society, its Origins and Founders*, 1960, 124) the expression "passing reference" is expanded into "full and generous credit".

The "one major addition to Boyle's writings since the first edition of this *Bibliography* was published" is the anonymous tract which appeared in *Chymical, Medicinal, and Chyrurgical Addresses made to Samuel Hartlib* . . . London, 1655, under the heading "Philaretvs to Empyricus"—attributed by Miss M. E. Rowbottom (*Annals of Science*, 1950, **6**, 376–89) as the earliest published writing of Robert Boyle. This tract has been assigned the number I (in square brackets) "to indicate that that is its logical and just place". Among the collated *Contents* of entry [I] ("Addresses to Hartlib") the reviewer has noted a misprint, e.g. "(*)3*a*-(†)4*b*" (translation of a "Theosophicall German treatise") should read "(*)8*a*-(†)4*b*".

It is pointed out that so far as possible the original numbers of the entries, in the book under review, have been preserved unchanged; in the first edition no numbers were given to the dedications listed under "D. Biography and Criticism". In the present edition "the individual items have been numbered and thus all subsequent numbers have had to be changed". We are given a list of these changes on page xxvi—not "xxiv" as misprinted in the preface.

Concerning the fate of Boyle's library, there is no longer the possibility that any part of it will be found intact. Professor Fulton's preface contains an account of the discovery (made independently by Douglas McKie and R. E. W. Maddison in 1949) that certain passages in Hooke's *Diary* provided a clue to the solution of this problem.

In regard to the *Sceptical Chymist*, the "reluctant conclusion" has been drawn that, from the standpoint of the history of science, this book is not Boyle's most significant work—a verdict that perhaps may not yet be generally accepted.

Turning to the section on "Epitomes", one notes the revised collation of Richard Boulton's edition of Boyle's *Works* (Vol. III), and that Vol. IV has also been included. It is stated that Volume IV "must be rare since it is seldom found with the first three volumes". The reviewer has, however, noticed that several complete copies of "Boulton" have appeared during recent years.

It is a pleasure to record that the publishers have provided this definitive edition of the *Bibliography* with a substantial binding—an important utilitarian feature of a book that will be so frequently consulted.

D. G.

PUBLICATIONS RECEIVED

The Two Netherlanders: Humphrey Bradley and Cornelis Drebbel. By L. E. Harris. Cambridge: W. Heffer & Sons, Ltd., 1961. Price 44s.

Transactions of the Newcomen Society, Vol. XXXI, 1957–59. London: Printed for the Society by W. Heffer & Sons, Ltd., Cambridge. Price 50s.

Erratum

In *Ambix*, 8, iii (October), 1960, p. 129, the opening sentence of note 11, ". . . Origen, *De Princip*, I, 7, 4, . . ." should read ". . . Origen, *De Princip.*, III, 5, 4, . . .".